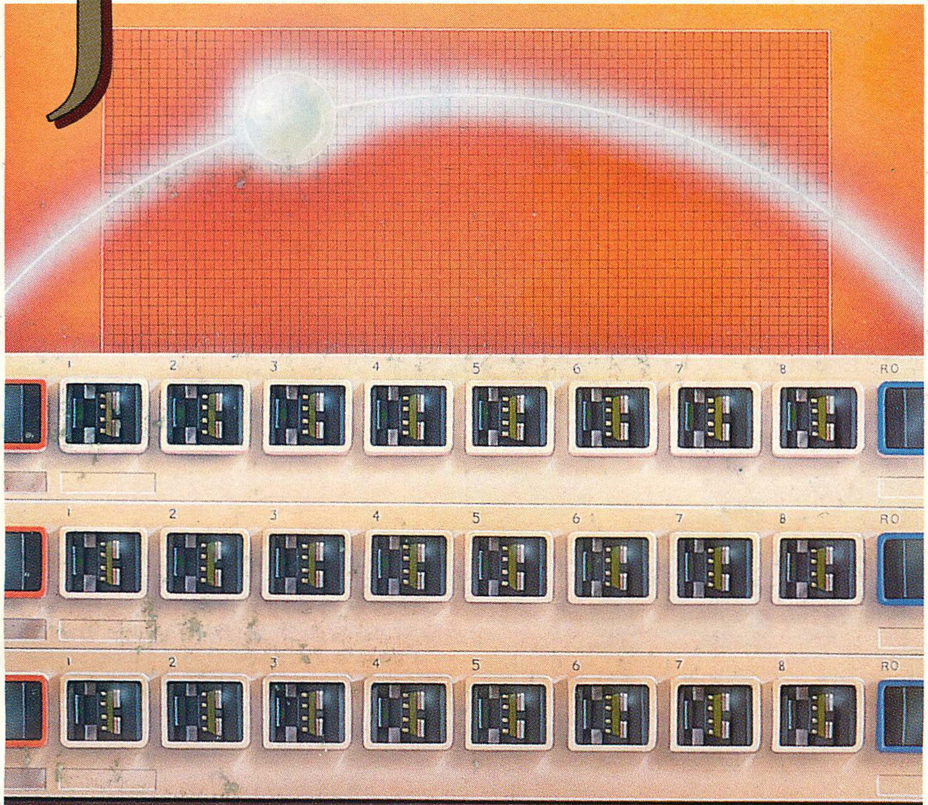
JANUARY 1987 VOL. 5 NO. 1 $3.95

FOR THE IBM SYSTEMS PROFESSIONAL

PC TECH JOURNAL®



TOKEN-RING NETWORK
IBM's Key to Connectivity

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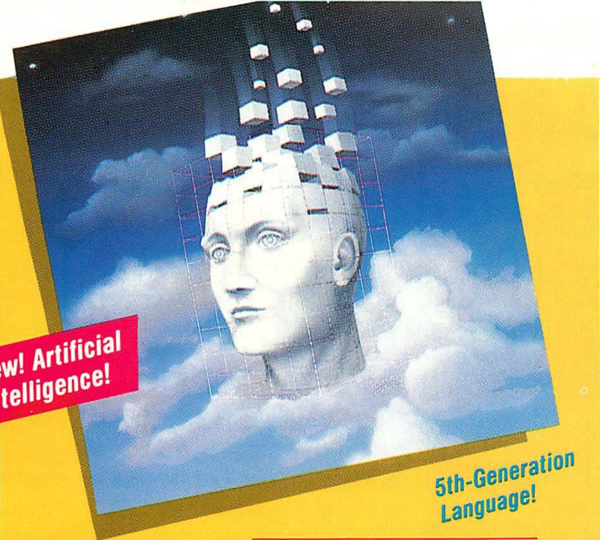


New! Artificial Intelligence!

5th-Generation Language!

$10.00 Scratch 'n Win Rebate!

Turbo Prolog™

"If you're at all interested in artificial intelligence, databases, expert systems, or new ways of thinking about programming, by all means plunk down your $100 and buy a copy of Turbo Prolog."
Bruce Webster, BYTE

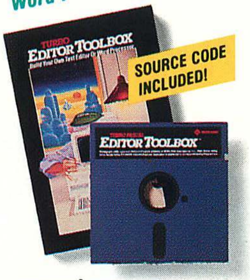
"Borland International, Inc. is gunning onto the fast track in the artificial intelligence and engineering-language-software race, riding aboard a new $99 Turbo Prolog," says Tom Schwartz in *Electronic Engineering Times.* And so we are. Our new Turbo Prolog has drawn rave reviews—which we think are well deserved—because Turbo Prolog brings 5th-generation language and supercomputer power to your IBM PC and compatibles. Turbo Prolog is a high-speed compiler for the artificial intelligence language, Prolog, which is probably one of the most powerful programming languages ever conceived. We made a worldwide impact with Turbo Pascal and you can expect the same results and revolution from Turbo Prolog, the natural language of artificial intelligence. Darryl Rubin, writing in *AI Expert* said, *"Turbo Prolog offers generally the fastest and most approachable implementation of Prolog."* Suggested retail, $99.95. Use a $10.00 Scratch 'n Win Rebate and that goes down to only *$89.95!* Minimum memory: 384K.

Technical Specifications:

TURBO PASCAL 3.0 Minimum memory: 128K; includes 8087 and BCD features for 16-bit MS-DOS and CP/M-86 systems. CP/M-80 version minimum memory: 48K; 8087 and BCD features not available. ***TURBO DATABASE TOOLBOX*** Minimum memory: 128K. CP/M-80 minimum memory: 48K. Requires Turbo Pascal 2.0 or later. ***TURBO GRAPHIX TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later, Turbo Pascal 3.0, and IBM CGA, Hercules Monochrome Card or equivalent. ***TURBO TUTOR 2.0*** Minimum memory: 192K. CP/M-80 version minimum memory 48K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO EDITOR TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO GAMEWORKS**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO PROLOG**** Minimum memory: 384K. ***REFLEX: THE ANALYST**** Minimum memory: 384K. Requires IBM CGA, Hercules Monochrome Card or equivalent. Works with Intel's AboveBoard-PC and -AT; AST's RAMpage! and RAMpage! AT; Quadram's Liberty-PC and -AT; Tecmar's 640 Plus; IBM's EGA and 3270/PC; AT&T's 6300 and many others. ***REFLEX WORKSHOP**** Minimum memory: 384K. Requires Reflex: The Analyst. ***TURBO LIGHTNING**** Minimum memory: 256K. Two disk drives required. Hard disk recommended. ***LIGHTNING WORD WIZARD**** Minimum memory: 256K. Requires Turbo Lightning. Turbo Pascal 3.0 required to edit source code. ***SIDEKICK**** Minimum memory: 128K. ***TRAVELING SIDEKICK**** Minimum memory: 256K. ***SUPERKEY**** Minimum memory: 128K. *For IBM PC, AT, XT, PCjr and true compatibles only, running PC/MS-DOS 2.0 or later.

Turbo Pascal Programming

Build Your Own Word Processor!



$10.00 Scratch 'n Win Rebate!

Turbo Editor Toolbox™

Recently released, we called our new Turbo Editor Toolbox a "construction set to write your own word processor." Peter Feldmann of *PC Magazine* covered it pretty well with, *"A 'write your own word processor' program for intermediate level programmers, with lots of help in the form of prewritten procedures covering everything from word wrap to pull-down windows."* Source code is included, and we also include MicroStar, a full-blown text editor with pull-down menus and windowing. It interfaces directly with Turbo Lightning to let you spell-check your MicroStar files. Jerry Pournelle of *BYTE* magazine said, *"The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PC-compatible text editor to do."* Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you'll get all this for *only $59.95!* Minimum memory: 192K.

MicroStar file directory accessed by pull-down menu

Borland's Business Productivity Programs:

Reflex: The Analyst® Analytical database manager. Provides complete, new look at data normally hidden by programs like 1-2-3® and dBASE.® Best report generator for, and complement to, 1-2-3.

Reflex Workshop™ Important new addition to Reflex: The Analyst. Gives you 22 different templates to run your business right.

SideKick® Complete RAM-resident desktop management includes notepad, dialer, calculator and more.

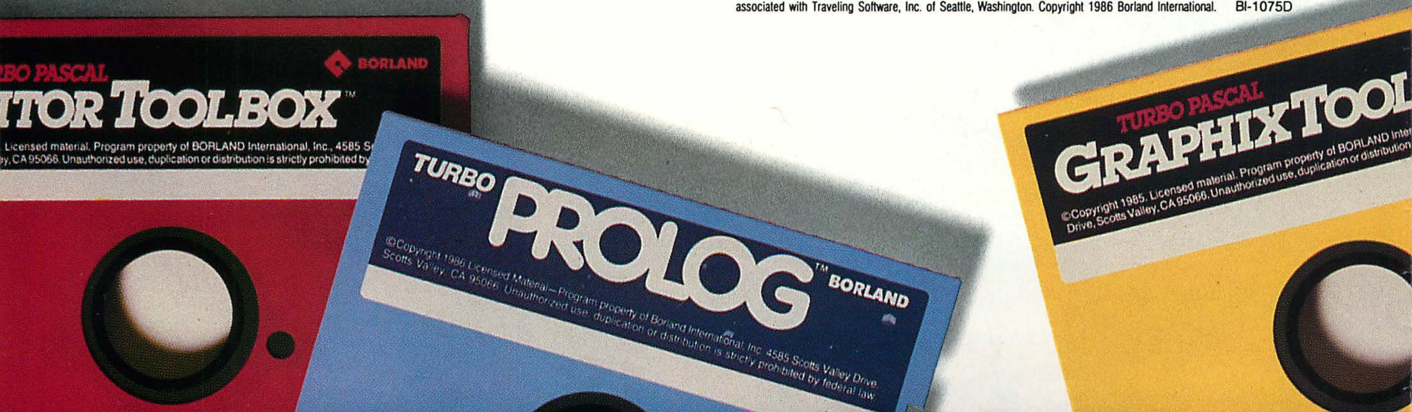
Traveling SideKick® Electronic version of business/personal diaries, daytime organizers; works with your SideKick files; important professional tool.

SuperKey® Keyboard enhancer. Simple macros turn 1000 keystrokes into 1. Also encrypts your files to keep confidential files confidential.

Borland's Electronic Reference Programs:

Turbo Lightning® Works with all your programs and checks your spelling *while you type!* Includes 80,000-word Random House® Concise Word List and 50,000-word Random House Thesaurus. Forerunner of Turbo Lightning Library.™

Lightning Word Wizard™ Includes ingenious crossword solver and six other word challenges. If you're into programming, Lightning Word Wizard is also a development toolbox and the technical reference manual for Turbo Lightning.



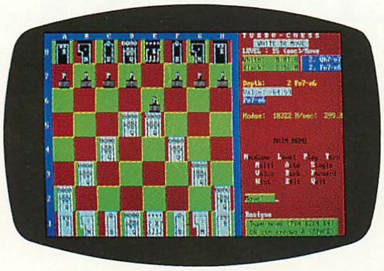
Turbo Pascal Programming

Learn Secrets, Strategies, Game Theory!

$10.00 Scratch 'n Win Rebate!

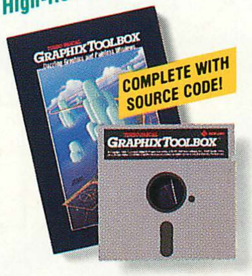
Turbo GameWorks®

Also recently released, Turbo GameWorks is what you think it is: "Games" and "Works." Games you can play right away (like Chess, Bridge and Go-Moku), plus the Works—which is how computer games work. All the secrets and strategies of game theory are there for you to learn. You can play the games "as is" or modify them any which way you want. Source code is included to let you do that, and whether you want to write your own games or simply play the off-the-shelf games, Turbo GameWorks will give hours of diversion, education, and intrigue. George Koltanowski, Dean of American Chess, and former President, United States Chess Federation, reacted to Turbo GameWorks like this: "*With Turbo GameWorks, you're on your way to becoming a master chess player.*" And Kit Woolsey, writer, author, and twice Champion of the Blue Ribbon Pairs, wrote, "*Now play the world's most popular card game—Bridge . . . even program your own bidding and scoring conventions.*" Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you're talking an *incredible $59.95!* Minimum memory: 192K.



Turbo GameWorks' Chessboard

Create Your Own High-Res Graphics!



$10.00 Scratch 'n Win Rebate!

Turbo Graphix Toolbox®

It includes a library of graphics routines for Turbo Pascal programs. Lets even beginning programmers create high-resolution graphics with an IBM, Hercules,™ or compatible graphics adapter. Our Turbo Graphix Toolbox includes all the tools you'll ever need for complex business graphics, easy windowing, and storing screen images to memory. It comes complete with source code, ready to compile. Suggested retail: $69.95, but with a $10.00 Scratch 'n Win Rebate, *only $59.95!* Minimum memory: 192K.

The Ultimate Learning Experience!

$10.00 Scratch 'n Win Rebate!

COMPLETELY NEW VERSION!

Turbo Tutor® 2.0

The new Turbo Tutor can take you from "What's a computer?" through complex data structures, assembly languages, trees, tips on writing long programs in Turbo Pascal, and a high level of expertise. Source code for everything is included. New split screens allow you to put source text in the bottom half of the screen and run the examples in the top half. There are quizzes that ask you, show you, tell you, teach you. You get a 400-page manual—which is not as daunting as it sounds, because unlike many software manuals, it was not written by orangutans. Suggested retail: $39.95. Use a $10.00 Scratch 'n Win Rebate and you're down to an *unheard of $29.95!* Minimum memory: 192K.

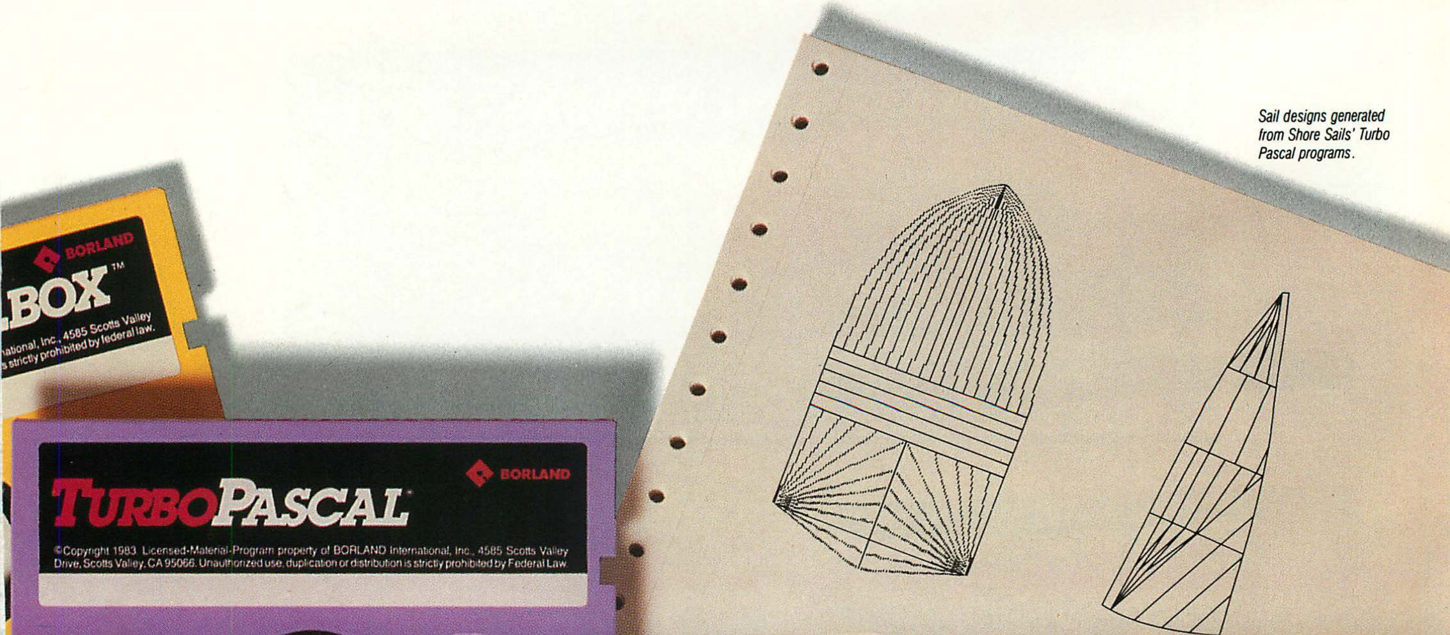
Recognition for Borland International has come from business, trade, and media, and includes both product awards and awards for technical excellence and marketing.

America's Cup. Coming Soon!

How to use Scratch 'n Win Rebates

It's really simple. You purchase the product between 9/5/86 and 3/31/87, and return the license agreement along with dated proof of purchase and your rebate card. We'll mail you a check for $10.00 on single product purchases or a check for $15.00 when you buy an advertised "bundle"—which means our Turbo Pascal Jumbo Pack, or Turbo Lightning and Lightning Word Wizard, or Reflex: The Analyst and Reflex Workshop, or SideKick and Traveling SideKick. (Restrictions do apply. See Official Rules on back of Instant Winner card).

BI-1075D



Sail designs generated from Shore Sails' Turbo Pascal programs.

Borland's award-winning software is the best Holiday present you can give yourself or anyone else

Any one of these Holiday presents could save your marriage, career, reputation and quite a few bucks.

When you give or get any one of these Holiday presents, every day's a Holiday, because you're giving or getting long-lasting software that's a lot more welcome to the Woman in your Life than vacuum cleaners, egg-beaters and ugly earrings. And the Man in your Life would rather have Turbo Prolog,™ Reflex,® Reflex Workshop,™ Turbo Pascal,® Turbo Lightning® or SideKick® than socks, ties and wrong-size shirts.

Turbo Prolog takes you by the hand into the brave new world of Artificial Intelligence

Artificial Intelligence is no substitute for the human brain (well, most human brains; you make your own list), but it is a fascinating new field, and we're leading it with our 5th-Generation Turbo Prolog. In fact, people are telling us that Turbo Prolog is "The most exciting product they've seen this year." So see it for yourself. Give it. Get it. You deserve it.

Turbo Pascal wins PC World's 1986 World Class PC Award for 'Programming Language'!

Give someone our Turbo Pascal "Jumbo Pack," but keep some of the precious pieces for yourself

There's so much in there—Turbo Pascal, Turbo Tutor,® Turbo Database,™ Turbo Graphix,® Turbo GameWorks,® Turbo Editor®—you can probably give someone else one or two of them. (Just keep the ones you don't have already and make the rest thoughtful, really inexpensive presents for someone's Turbo Pascal library.)

Give them one, maybe two kinds of Holiday Reflex action!

Adam B. Green, InfoWorld's highly respected columnist, says "*Everyone agrees Reflex is the best-looking database they've ever seen.*" Peter Norton of PC WEEK says, "*The next generation of software has officially arrived.*" And now, with our brand-new Reflex Workshop, which includes 22 instant ways to run your business well, you can give someone both programs and just about guarantee them a Happy well-run New Year!

Turbo Lightning wins the 1986 World Class PC Award for "Most Promising Newcomer"!

Solve your gift-giving and spelling problems now with Turbo Lightning

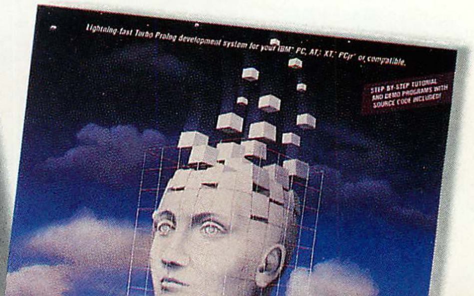
While you use SideKick, Reflex, Lotus 1-2-3® and most popular programs, Turbo Lightning proofreads *as you write!* If you misspell a word, Turbo Lightning will beep at you instantly, and suggest a correction for the word you just misspelled. Press one key, and the misspelled word is immediately replaced by the correct word. And if you're ever stuck for a word, Turbo Lightning's thesaurus is there with instant alternatives. Perfect gift for everyone who reads and writes!

Attention SideKick users! Your SideKick now has a sidekick!

If you're going anywhere for the Holidays, you'll need a Traveling SideKick!

It's the electronic organizer for this electronic age—a professional binder, a software program and a report generator—a modern business tool that prints your ever-changing appointments in daily/weekly/monthly/yearly form. Your appointments, phone list, address list, meeting schedule, travel itinerary—even your mailing list—can be kept up-to-the-minute correct *and with you!* (SideKick Owners: All your files translate instantly to Traveling SideKick.) Traveling SideKick is electronic, so it's good for this year, next year and all the next years after that—it's not a dusty old diary that dies Dec. 31!

BI-1075D



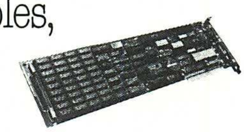
Borland's Instant Winner Game

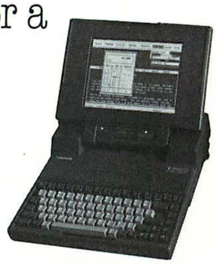
Scratch this card now and you could *instantly win* 2 free round-trip airline tickets to Australia for the America's Cup Race!

$10,000

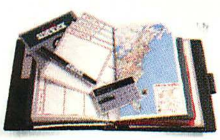
First Prize ($10,000 value!) includes accommodations for two in Perth, Australia during the final America's Cup races, which start January 31, 1987. See America win it back after our *only* loss in 134 years! There's more than one *instant winner* in Borland's Instant Winner Game, because you could win one of two new $6,895 4-WD Suzuki Samurai convertibles, or a $4,995 AST TurboLaser™ printer, or a $4,499 Toshiba T3100,™ or a $2,399 Toshiba T1100™ Plus, or a $595 AST SixPakPremium™, or a $69.95 Traveling SideKick,® or any one of hundreds of other Borland products—and at the very least a Borland Rebate Coupon, good for $10 off any single product or $15 off any bundled product offer!

$6,895





$4,499



$69.95

See Official Rules on the back of this card for details.

Don't delay! There will be a second-chance drawing for the trip if not claimed by 12/30/86. There's also a second-chance drawing for the two Suzukis if not claimed by 2/26/87. All rebate coupons are good for products purchased 9/5/86-3/31/87. Product prices above are suggested list prices.

Rub the silver box to reveal whether you win a prize or get a rebate coupon. Then fill in the second-chance entry blank to the right.

Second-Chance Sweepstakes Entry!

We're running two Second-Chance Sweepstakes drawings to award the trip and cars. They *will be won* by someone—it *could be you!* Fill in the entry coupon and mail it now. Winners will be notified immediately, because the final America's Cup races start in Australia on January 31, 1987, and you'll have to pack in a hurry.

(You will need a valid passport and the ability to comprehend Australian versions of the English language.)

Name ____________________

Address ____________________

City ____________________

State __________ Zip __________

OFFICIAL RULES - BORLAND INSTANT WINNER GAME

1. NO PURCHASE NECESSARY: To participate, you may obtain a game card inserted into the October, November, December, or January issue of the following magazines: PC World; Byte; PC Tech Journal; PC Magazine. You may also obtain a game card by mailing a self-addressed, stamped envelope to: Borland International Game Card, P.O. Box 870, Wilton, CT 06897. (Washington State residents send self-addressed envelope.) Limit one game card per stamped request. All requests must be received by January 15, 1987.

2. TO PLAY: Remove the rub-off area on the game card to reveal what prize or rebate offer you have obtained.

3. PRIZES/REBATES: Beneath the rub-off area one of the following prizes may be revealed: Trip for Two to America's Cup Races or $10,000; 1986 Suzuki 4W Samurai Convertible or $6,895; AST Turbo Laser, Toshiba 1100 Portable Computer, Toshiba *3100 Portable Computer, AST Sixpakpremium*; AST Advantagepremium; AST3G Pak; AST Rampage; AST Rampage AT; Free Borland Product, or you may obtain the following rebate offer: $10 rebate offer on any individual product or $15 rebate offer on any single advertised Borland bundle (See rule #11 for prize details.).

4. PRIZE CLAIMS: If you obtain one of the prizes stated in Rule #3, sign your full legal signature on the game card and send via certified mail (copy should be made for your records) along with your name and address to: Borland International Prize Claim, 196 Danbury Road, Wilton, CT 06897. All prize claims must be received or postmarked by February 15, 1987. (See Rule #12 for Trip for Two to America's Cup exception.)

5. REBATE CLAIMS: Rebates are good for products purchased from September 5, 1986 through March 31, 1987. The $10 rebate is good for any individual Borland product and the $15 rebate is good for any advertised Borland software bundle. To receive your rebate you must return your completed license agreement from the manual, this game card and dated proof of purchase to: Borland International, Game Card Rebate, 4585 Scotts Valley Drive, Scotts Valley, CA 95066. Upon receipt of the license agreement, game card and proof of purchase, Borland will send your check. Rebate is not valid with any other rebate or promotion offered directly from Borland.

6. VERIFICATION: All game materials are subject to verification. Game materials are void and will be rejected if not obtained through authorized, legitimate channels, and may be rejected if any part is reproduced, counterfeited, torn or altered in any way, or if materials contain printing, typographical, or mechanical errors. Decisions of the Redemption Center are final. Game pieces from any game other than the Borland Instant Winner Game may not be used in this game.

7. CONDITIONS OF PARTICIPATION: Material submitted becomes the property of Borland International. The submission of game pieces is the sole responsibility of the individual seeking verification, who is solely responsible for lost, late, or misdirected mail. All taxes, registration and inspection fees are the sole responsibility of the verified winner. Winners may be required to execute an affidavit of eligibility and name and likeness publicity release. By participating in the game you accept and agree to be bound by these rules and the decision of the Official Redemption Center which will be final.

8. ELIGIBILITY: Participation is open solely to residents of the United States 18 years of age and over, except employees and agents of Borland International, service agencies, and individuals engaged in the development, production, or distribution of game materials, The Merritt Group, Inc. and their immediate family or members of their households. Void in Vermont and where prohibited by law.

9. GAME SCHEDULE AND AWARD OF PRIZES: The Borland Instant Winner Game will commence on or about September 5, 1986 and end on January 30, 1987. It will officially end, however, when all game pieces are distributed. Verified game prizes will be awarded within thirty (30) days from the date of their receipt for verification at the Official Redemption Center. A major prize winners' list can be obtained by sending a stamped, self-addressed envelope to: Borland Instant Winner Game Winners' List, P.O. Box 7089, Wilton, CT 06897.

10. ODDS CHART: The odds of winning prizes are based upon obtaining the one rare game piece among the applicable number of game pieces.

PRIZE	Qty.	Total Value	Odds of Winning
Trip for Two to America's Cup or $10,000	1	$ 10,000.00	1 in 6,458,000
Suzuki 4W Samurai Convertible JA or $6,895	2	$ 13,790.00	1 in 3,229,000
AST Turbo Laser	1	$ 4,995.00	1 in 6,458,000
Toshiba Portable Computer	2	$ 6,898.00	1 in 3,229,000
AST Memory Boards	25	$ 15,025.00	1 in 258,320
Borland Products	1,000	$149,000.00	1 in 6,458
OVERALL TOTAL	**1,031**	**$199,708.00**	**1 in 6,264**

All remaining game cards will contain a $10 rebate good on any individual Borland product or a $15 rebate good toward any advertised Borland software bundle.

11. PRIZE DETAILS: Trip for two to America's Cup Races (or $10,000) will include coach seating round trip airfare on regularly scheduled commercial airline from San Francisco, California to Perth, Australia and up to two weeks hotel accommodations in Perth, Australia plus $4,500 spending cash. Winners will be responsible for obtaining visa, passport, and all other travel documents. Trip does not include meals, taxes, excess baggage charges and other hotel charges. Minor must be accompanied by parent or legal guardian.

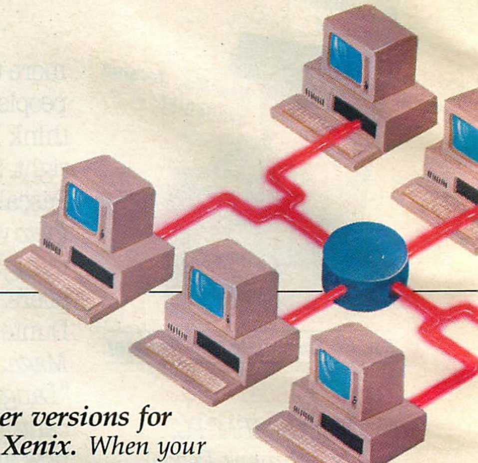
Suzuki 4W Samurai Convertible JA Standard Equipment Package (or $6,895), verified winner will be responsible for all registration, insurance, and licensing fees. AST Turbo Laser, Toshiba Portable Computer Model #T1100; Toshiba Portable Computer Model #T3100; AST Memory Boards and Free Borland Products are non-substitutional except by sponsor due to product availability and all warranties and guarantees are subject to manufacturers terms. All prizes are non-transferrable. Winning consumer is responsible for all local, state and federal taxes.

12. SECOND CHANCE SWEEPSTAKES: There are two Second Chance Sweepstakes drawings scheduled to be conducted on December 31, 1986 and February 28, 1987. Random drawing from all entries received by December 30, 1986 will award trip for two to America's Cup Races (or $10,000). Random drawing from all entries received by February 26, 1987 will award two (2) Suzuki 4W Samurai (or $6,895). All remaining prizes that are unclaimed after February 15, 1987 will remain unclaimed. Send entry to: Second Chance Entry P.O. Box 870 Wilton, CT 06897.

If you have any questions concerning the Borland Instant Winner Game, call: 1-800-451-4471.

Btrieve.®

The Programmer's Choice.



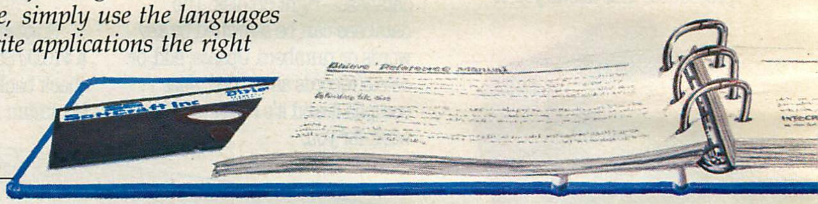
When you're serious about application development, there's just one choice for file management: Btrieve. With what *Computer Language* calls "near mainframe functionality[1]", Btrieve sets the file management standard for PC applications. With Btrieve loaded in your PC, your programs can use simple subroutine calls to retrieve, store and update records.

Multi-user versions for LANs and Xenix. *When your applications need to network, count on Btrieve. A single version runs on all DOS 3 LANs, including IBM PC Network and Novell Advanced Netware. Btrieve is also available for Xenix and multitasking operating systems such as MultiLink Advanced, Microsoft Windows and IBM Topview.*

B-tree based for high performance. *Performance is all-important, especially as your database grows. That's why Btrieve implements the b-tree file structure—the fastest, most efficient method of accessing data.*

Interfaces to C, BASIC, Pascal, COBOL. *Don't waste time programming in awkward fourth generation languages! With Btrieve, simply use the languages you know best—and write applications the right way. Over 15 language interfaces available.*

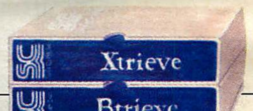
Built-in security features. *Lock up sensitive data with Btrieve's password protection and unique data encryption scheme—especially useful in local area networks.*



Help is just a phone call away. *Need technical support? You've got it! Btrieve users receive 30 days of unlimited phone support at no charge. This "Direct Connect" policy is renewable for a full year at low cost. And try SoftCraft's free bulletin board for technical tips, seven days a week.*

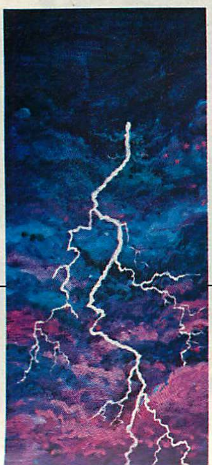
Thorough documentation, easy implementation. *Getting started with Btrieve is easy: the manual is packed with examples of every Btrieve function in BASIC, Pascal, COBOL and C.*

Database queries, report writing. *Add Xtrieve™ to your Btrieve applications for a fully-relational DBMS. Xtrieve's menu-driven interface gives your users the on-line query capabilities they need—without programming. Add our report writer option to produce custom reports and forms.*



No royalties. *Need we say more?*

Fault tolerant. *Btrieve insures against database disasters. Two levels of fault tolerance guarantee data integrity during accidents or power failures—even if lightning strikes. No extra programming required.*



SoftCraft

P.O. Box 9802 #917 Austin, Texas 78766 (512) 346-8380 Telex 358 200

Suggested retail prices: Btrieve, $245; multi-user Btrieve, $595; Xtrieve, $245; multi-user Xtrieve, $595 (for report generation, add $145 for single-user and $345 for multi-user). Available from SoftCraft and selected distributors. Requires PC-DOS or MS-DOS 2.X, 3.X, Xenix. Btrieve is a registered trademark and Xtrieve is a trademark of SoftCraft Inc. [1]From Computer Language, November 1985.

CIRCLE NO. 201 ON READER SERVICE CARD

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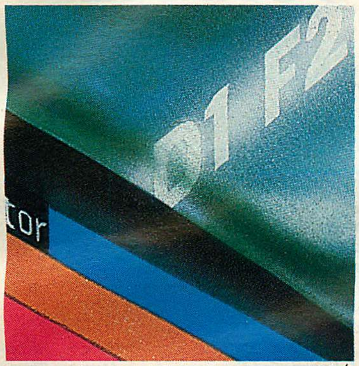
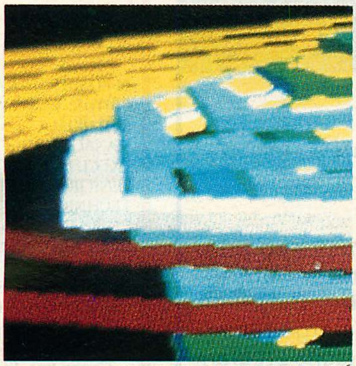
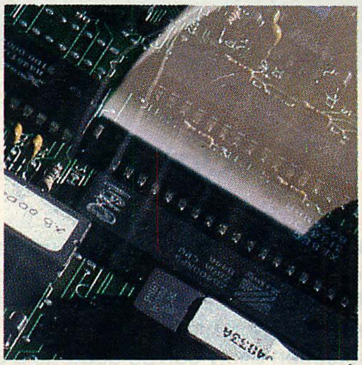
JANUARY 1987 VOLUME 5, NUMBER 1



Display Adapter Bottleneck 104



A Message-Passing Executive 126



Mass-Storage Mergers 76

Cover illustration · Andy Levine

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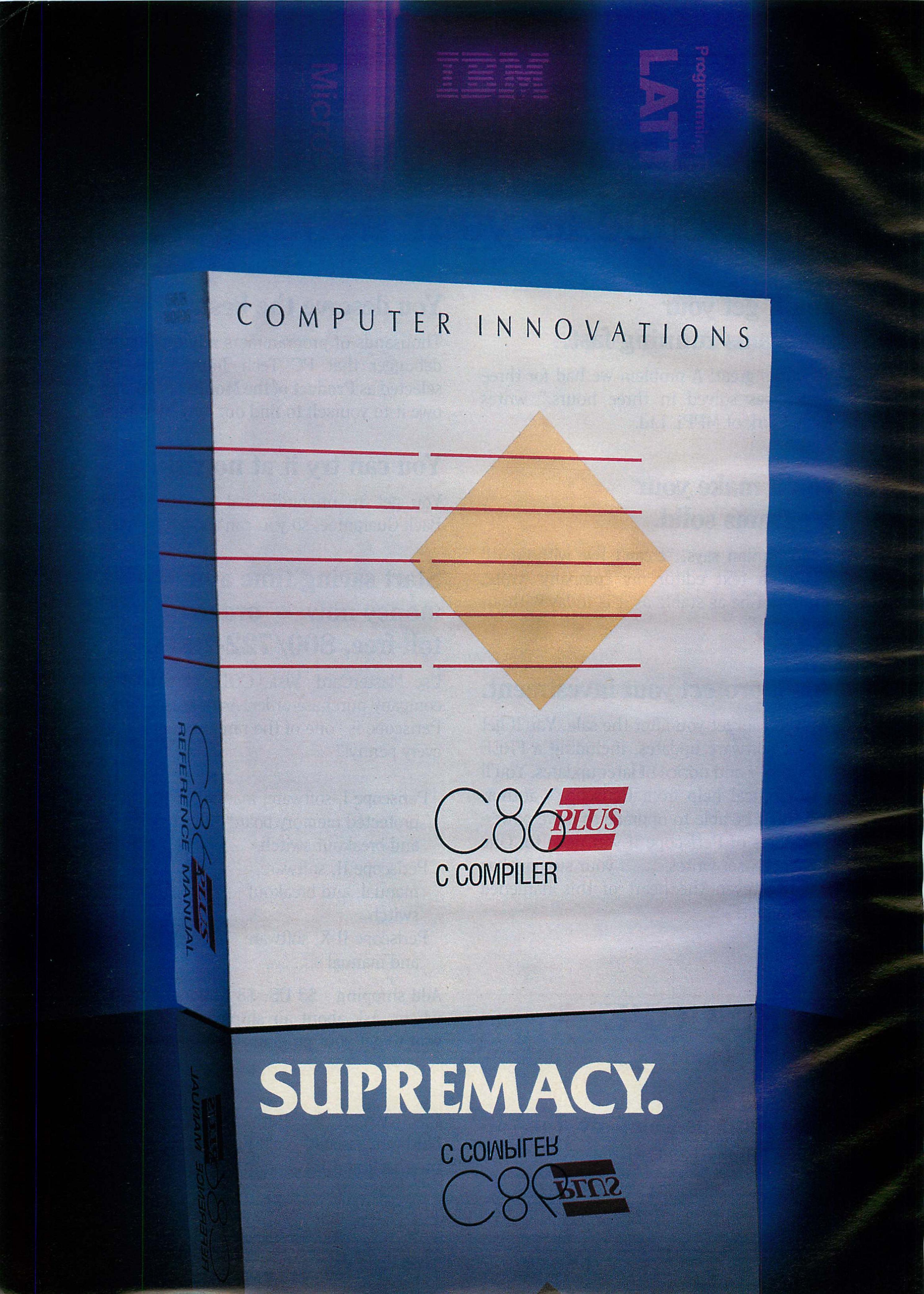
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CIRCLE NO. 144 ON READER SERVICE CARD

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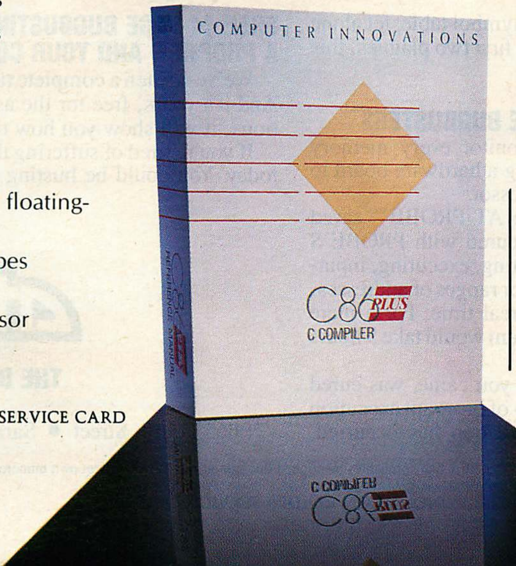

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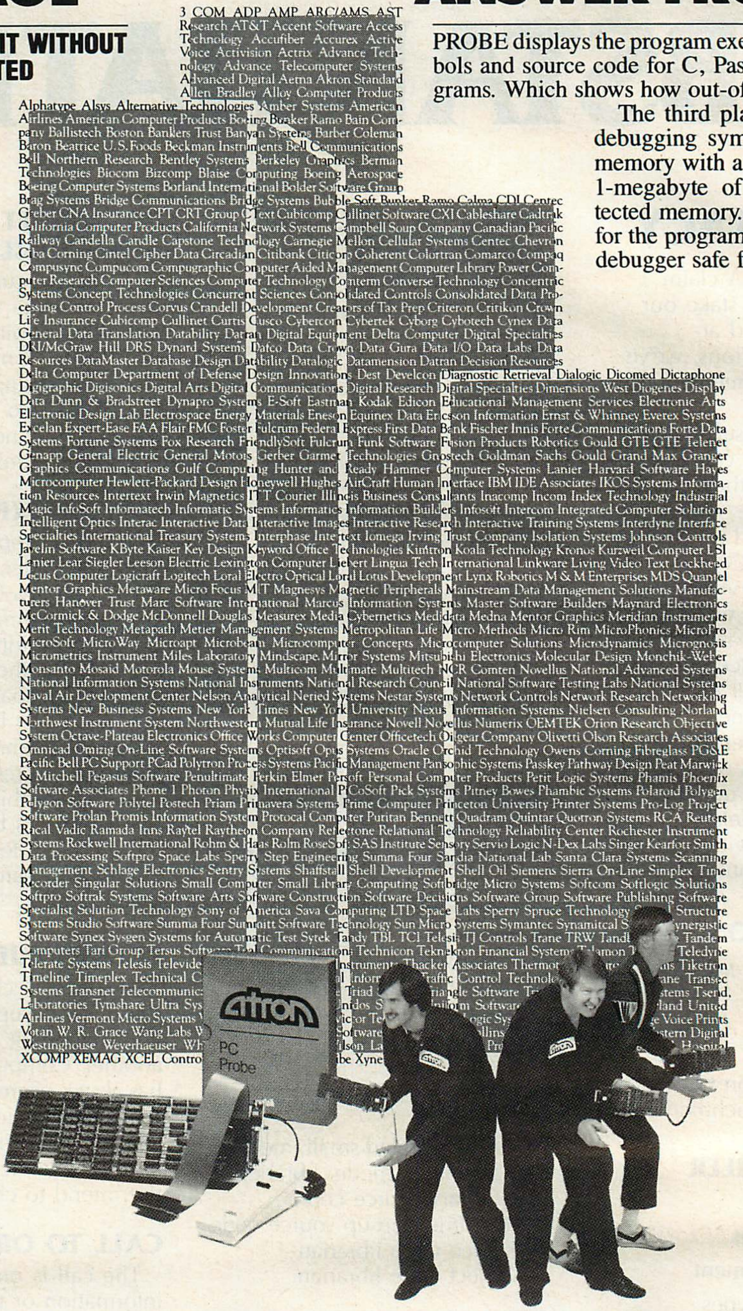

PLAGUES OF BIBLICAL PROPORTIONS

The first and most difficult plague was impossible to trap with software debuggers. These were carnivorous bugs which randomly overwrote programs, data, even the debugger. Nastiest were the ones that slipped in once every few hours, or changed their behavior after each new compile. Forty days and forty nights of recompiling, *trying something else*, caused many a would-be resident of the city to run screaming into the wilderness, never to be heard from again.

Second came the plague of not knowing where the program was, or where it had recently been. This compounded the first plague: How could anyone know *what* caused the random memory overwrites? Add to this random interrupts and timing dependencies, and you begin to understand *The Fear* that gripped the city.

Then came the last plague, which brought the wizards to their knees before they even started debugging. Their towering programs consumed so much memory, there wasn't enough room for their symbol table, let alone debugging software. Even if they could get past the first two plagues, this one killed their firstborn software.

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The second plague, not knowing from whence you came, was cured with PROBE'S real-time trace memory. The history of program execution is saved on-board, in real time. Once a hardware trap has occurred, PROBE displays the program execution in detail, including symbols and source code for C, Pascal, or assembly language programs. Which shows how out-of-range pointers got that way.

The third plague, not enough room for the debugging symbol table to be co-resident in memory with a large program, was cured with 1-megabyte of on-board, hidden, write-protected memory. System memory was then free for the program, keeping the symbol table and debugger safe from destruction.

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CIRCLE NO. 203 ON READER SERVICE CARD

The Printer Standards Gulf

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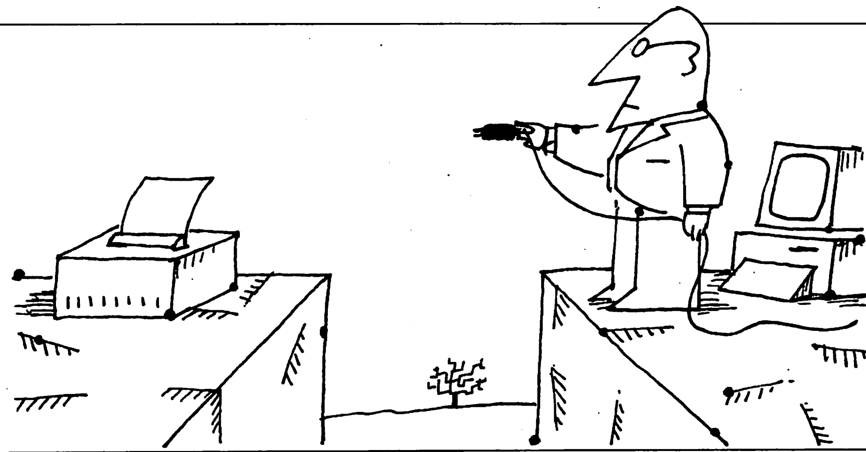


ILLUSTRATION • MACIEK ALBRECHT

The hype at Fall COMDEX was, I am sure you have already read, about 386 machines and 286 machines and laser printers and desktop publishing. What really grabbed me was the huge number of new printers introduced, including many dot-matrix devices.

I have to confess a certain disappointment, however. While I like many of the new printers, I see no progress being made toward better standards for this most important and ubiquitous peripheral device on the desktop. This is a problem for the end user who is confronted by a bewildering array of options but with no certain reassurance (unless the salesperson ignores the facts) that the printer will be compatible with his or her software.

The lack of standards is also a significant problem for the developer. Any software product must either target itself against the lowest common denominator (a text printer that can backspace) or deliver a multitude of printer drivers so that more advanced printer features can be exploited. This translates into a major support problem, as user after user calls the hotline asking for help: "I'm trying to print on my NOSPE XM-08 and..." The problem is exacerbated by laser printers, which typically offer a long list of fonts in a variety of styles and sizes.

When I first got involved with personal computing, the world of printers seemed to consist of a few daisy wheels and a lot of dot matrix printers made by Epson. Few options were available, and those that were tended to be expensive; the very popular GrafTrax ROM set that delivered all-points-addressable graphics to the printer represented a fairly high cash outlay compared with the price of the printer.

Software would arrive on my doorstep with the bold announcement that it supported the Epson MX-80. We reviewers of the IBM PC left no stone unturned trying to verify that the IBM PC Graphics Printer was, in fact, nothing more than an ivory-colored version of the MX-80. Soon software began to arrive with the bold announcement that it supported the IBM printer.

Suddenly, the floodgates opened. Dozens of printers burst forth, each promoting its own set of new features and enhancements, and each insisting that it properly emulated the Epson FX-80 or the Diablo 630. But therein lies the rub: most of the emulations were not perfect, often prompting the user to ask, "Why didn't I just buy the Epson in the first place?"

By now, the more recent market entries should have considered these compatibility issues, but, in fact, most have not, opting instead for proprietary schemes that further compound the problem. Is the HP LaserJet+ emulation in the Epson GQ-2000 and Okidata LaserLine 6 laser printers correct?

This leaves today's developer with little choice. For example, WordPerfect comes with 200 printer definitions and a program that allows the user (not the novice, though) to build a definition for an unsupported printer or modify any of WordPerfect's definitions as needed. The latest version, WP 4.2, comes with a program that explains how the company has defined each printer as to supported features and fonts.

A possible light at the end of this dark tunnel is Microsoft Windows. A big advantage for the software developer is that Windows-compliant programs can take advantage of the Windows virtual device interface. Thus, the program just writes to the printer without worrying about what kind of printer it is; Windows then translates to a driver that understands the specifics for the particular printer. Although this is helpful, it really just transfers the burden of device driver development from the application developers to the operating system developers or, hopefully, to the device manufacturer.

FOUNDATIONS

What we need instead is a better base standard. Most printers today have a microprocessor controlling their operation, as well as memory. More memory, to hold character tables, fonts, or emulation programs, is not going to affect the cost of the printer by very much. If that's the case, then why don't we agree on a few simple features that would be included in every printer:

Characters. Let's agree that the IBM character set is a good one. It has, more or less, what we expect in positions 0 to 127. In the upper half, it includes foreign characters and a good set of line drawing characters for making simple

NEW FACES

Since I last wrote in this space about our staff (November 1985), a few changes have occurred.

We continue our policy of requiring that our technical staff possess significant computer industry experience, and our recent additions are no exception. Jim Shields has joined us as senior technical editor concentrating on the many PC-to-mainframe issues that we will cover in the future. Jim came to us from the U.S. Nuclear Regulatory Agency and 16 years of government service in a variety of computer-related positions; he was five times honored with awards for performance and service. He holds an M.S. degree in computer science from the University of Maryland, a B.S. in physics from Indiana University, and is a member of Phi Beta Kappa.

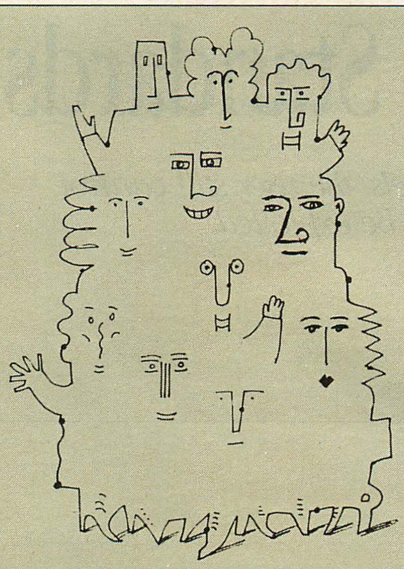
Technical editor David Methvin is our principal investigator into local area networks. He holds B.S. and M.S. degrees in computer science from the University of Virginia and brings extensive experience in C, UNIX, and networks gained from a variety of technical positions. David received achievement and management performance awards while at General Electric and joins us from a local company where, as a senior member of the technical staff, he worked on the development of a digital voice and data communications network.

When we consolidated our offices and moved the art department from New York to Columbia, art director Ina Saltz declined to make the move. Her contributions to the magazine have been significant; our clear visual identity is her legacy.

Replacing Ina as art director is Paula Jaworski, who worked for eight years at *Baltimore Magazine*, most recently in the dual role of art director and production manager. She is a magna cum laude graduate of the Maryland Institute, College of Art and holds a bachelor of fine arts degree. We are delighted to have Paula, the product of an exhaustive recruiting effort, and we are confident she will continue our award-winning ways.

Our new art assistant is Maria Sese, a 1986 graduate of the University of Maryland with a B.S. in advertising design and a knockout portfolio.

On the copy editing side of the house, Susan Holly has received a richly deserved promotion to chief



copy editor. In addition to considerable responsibility on our regular issues, which could best be described as watching over every word we print, Susie was the managing editor of the *PC Tech Journal Directory*. A journalist by training with both bachelor's and master's degrees from Indiana University, Susie supervises our recently expanded copy editing department, which now includes two tremendously talented proofreaders, Bruce Ansley and Beth Wardlaw.

Beth has a master's degree in library science and a publications specialist certificate from George Washington University. Bruce, a recent transplant from Texas to Maryland, has a B.A. in English from the University of Texas at Austin, and extensive electronic typesetting experience.

I am delighted to announce the promotion of Carole Autenzio to the position of new products editor, a change we made last year. Carole continues as *PC Tech Journal*'s primary liaison with vendors and public relations firms. She handles the flow of all press materials, as well as the actual products we review. More recently, Carole assumed the additional responsibility for the supervision of our lab, PCTECHline, and in-house computers.

Trish Ledbetter is my new assistant, who also fills the pivotal position of office manager for our Columbia facility. She was previously employed by the federal government where she gained 10 years of experience as secretary and administrative assistant.

We have a great team. It's the best way to make sure *PC Tech Journal* lives up to your expectations.

—*WF*

boxes. The set could probably be enhanced with just a few more characters and could suffer the deletion of a few, but, by and large, it is a suitable selection for most work.

Character extensions. Let's agree that the basic machine should include a facility for loading alternate characters, either as large sets or individually. Let's agree further that the mechanism should not disable the basic set, but simply extend it. Access to the extended characters should be easy to program and understand; it might involve set-switching commands or set-identifier prefixes.

Fonts. Let's agree upon a uniform method for loading and accessing fonts. This is certainly more complex than handling characters, but the reality is that it requires only memory for storage of the font and software to drive it. Access to characters in the font should be transparent—that is, once a font is selected, printing a character in the font should be the same as printing a character in the base character set.

Styles and sizes. Let's agree on a few basic styles (for example, italics, bold, and bold italics) and sizes (10, 12, and 17 pitch, with appropriate heights). In the basic printer, all combinations of these styles should be legal, with easy access to the features.

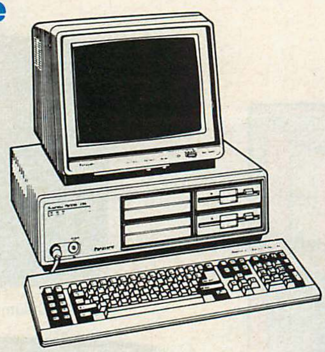
Page mode. Let's agree that even the simplest, dot-matrix printer is a page-oriented printer as far as graphics are concerned. Although the machine might not have enough memory actually to hold a full-resolution image, it should provide simple and intuitive ways to receive sizable chunks (larger than one line) of the image. Further, for real page (that is, laser) printers, landscape mode should not exclude anything in the base character set.

Commands. Let's agree to a simple command set for the base features and provide rational command sequences to invoke vendor-specific features. In other words, a specific escape sequence would always mean that the printer would enter the vendor's domain, within which the printer operates as that vendor wishes and not necessarily in accordance with the standard.

Building a printer in this manner would give the software developer a definite standard to which he may write with confidence, one that is richer than the ordinary text printer with backspace. It is getting to the point that software arrives with one program diskette and six diskettes full of printer drivers. Let's see if we can't find a way to whittle that down.

CODE BLUE

Hardware



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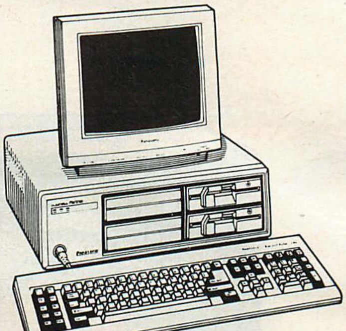

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A SAFE PORT

"Beyond COM2," Augie Hansen's review of multiport boards for the PC (September 1986, p. 68) was excellent. Mr. Hansen obviously researched the subject well and diligently tested each board. The article was extremely informative, and both Mr. Hansen and *PC Tech Journal* are to be commended.

I believe that the information as it was presented is a fair assessment of the boards included. However, between the time the article was begun and when it was completed, several improvements were made to the HOSTESS board from Control Systems. These changes should be mentioned so that a better comparison can be made.

First, table 1 listed DOS, QNX, and SCO XENIX compatibility. HOSTESS is also compatible with IBM XENIX 1.0 and 2.0, THEOS, VENIX, PICK, PC/RTX and AT/RTX, INETCO Coherent, and OPUS V. Many of these have drivers built-in for the HOSTESS.

Second, the article stated that, "No driver software is sold with the board itself." Up until April 1986, Control Systems sold either a DOS driver or an IBM XENIX 1.0 driver *if* the customer requested it. Since that date every HOSTESS board is shipped, according to the customer's request, with either a DOS driver (HOSTBUFFER) or IBM XENIX 1.0 driver, at no charge. A XENIX 2.0 driver has been available since August 1986 and is also included at no charge when ordered with a HOSTESS board. Each of these drivers costs $20 when ordered separately.

Finally, no mention was made of the different interfaces and/or connectors provided with HOSTESS. They are as follows: RS-232, 25-pin, male or female; RS-232, 9-pin, female (a male version will be available soon); selectable RS-232/Current Loop, 25-pin, female; RS-422/485, 9-pin, female; and, to be released soon, a selectable RS-232/RS-422, 25-pin, male or female.

I feel that the HOSTESS board is more fairly represented given the above information. Thank you for this forum.

Walter J. Stull
Control Systems, Inc.
St. Paul, MN

TAKEN TO TASK

With regard to Jim Roberts' review of TAS-Plus version 2.04 in the October 1986 issue ("A Data Manager for the Self-Reliant User," p. 146), I would like to make the following response:

First, I would like to keep our comparisons in one arena. We compare our product to DBASE III PLUS, not Oracle or Progress. No, we do not have automatic data-recovery facilities, but then, neither does DBASE. Mr. Roberts mentions throughout the article that certain actions may have catastrophic effects on the data. This is not quite true.

TAS-Plus uses the facility that DOS offers to open duplicate handles and close them without affecting the original handle. This has the effect of forcing the buffers to the disk and updating the directory information after each write so that should the system fail, the data are maintained. This works very well. In fact, even when I have been debugging the program and have aborted in the middle without exiting properly, the data I entered just before I quit were still there—including the keys.

In response to Mr. Roberts' complaints about burying references in the documentation, I submit the following: on page 148 (of the article), he remarks that a "crucial warning has been thoughtfully buried." That warning had to do with allowing fields to contain negative numbers. The main heading for that section (in our documentation) is "Conventions in TAS-Plus Programming and Documentation." The subchapter heading is "Fields." A reference is made to "Fields" in the index for the same page. We refer to fields early on and often in the documentation.

Mr. Roberts also states that he had problems with the structure rules (or block rules, as he calls them). However, he simply needs to understand how to use braces in denoting the structure. Our reference section for those commands refers to a tutorial chapter that states very plainly that you may not do a **goto** or **gosub** into the middle of a structure. (We work constantly on improving our documentation. A new manual will be issued in the near future. In the interim, improvement is accomplished through errata sheets.)

Many of Mr. Roberts' complaints have been fixed in the 2.06 release, which we began shipping in early October 1986 to all registered users.) This release includes the ability to print file schemas and to add new fields to the middle of an existing schema; changes also were made to the screen editor and new commands were added.

I designed TAS-Plus as a business programming tool. (TAS is an acronym for "the accounting solution.") It is intended to be an alternative to DBASE and all of its clones: a program with enough power to create sophisticated or simple business programs that could be used by novice or accountant.

Mr. Roberts skims over many of our unique features. In what other fourth-generation language could you write source-code editors, screen editors, and browse utilities? You can have a different help message available at each entry location. And you can open 32 files in the developer version—that means 32 master and 32 key files (16 in the base TAS-Plus version). No, we do not include many scientific number-crunching features. This program was not designed for those purposes.

The proof of our success is in our sales. We have sold more than 10,000 copies of the product. The number of people who have written to state their satisfaction with the product is heartening. These people range from novices

who have never programmed in any language to sophisticated programmers.

In closing, I would like to thank Mr. Roberts for the kind words he had to say about me. I will continue to improve on this product and keep it in a price range that anyone can afford.

Philip D. Mickelson, president
Business Tools, Inc.
Bellevue, WA

As we stated at the outset of our series on data managers, we review one product at a time rather than comparing many products at once. Each product is reviewed against a set of criteria we considered important in an ideal data manager, rather than against any existing product. Progress and Oracle were referenced merely as examples of products that provide desirable data backup and recovery features.

—JS

Mr. Mickelson misses the point, as does the documentation, on the use of compound statements ("structures"). Transfers entirely within a compound statement are allowed in every structured language I know, except that of TAS. Worse yet, as is often the case in TAS-Plus, no diagnostics are produced by the compiler when this unusual restriction is not observed.

I hope Mr. Mickelson is correct that many of the problems I encountered with TAS-Plus have been fixed in version 2.06; however, I have not as yet received a copy of this release, even though I am a registered user.

—Jim Roberts

HE LOST HIS MEMORY

I have been using Logitech's Modula-2 system for a short time, so I was interested in your September 1986 article ("Modula-2/86 Base Language System," Product Watch, John T. Cockerham, p. 187). Unfortunately, your reviewer overlooked one major problem: the Modula-2 is a memory hog.

I have had frequent problems with the compiler aborting in the middle of a compilation, reporting that it is unable to load one of its overlay files. After some investigation, I concluded that this is because of Modula-2's poor memory management. Over the course of several edit-compile-edit cycles, Modula-2 consumes so much memory that not much room is left for overlay.

To test, I loaded a file consisting of a MODULE declaration, a four-line comment, and an END declaration (with Modula-2 reporting 214KB available memory). I typed in the same comment again, so that I ended up with two copies of the comment in the program. Modula-2 then reported 151KB available. I tried to compile the program, and Modula-2 was unable to load the overlay file. After failing to compile, it reported 150KB available. I tried to compile again and Modula-2 consumed another 1KB of memory.

After I saved the file to disk I exited to DOS. DOS reported that the file was 736 bytes long, but it tied up 65KB of memory when the file was created in the editor and compiled twice. Upon reentering Modula-2 and reloading the file, Modula-2 reported 214KB available, finally agreeing that this was a small file. Then it compiled the file with no problems.

Modula-2's editor does a terrible job of managing memory when it is inserting text in the middle of a file. The only way around this problem that I have found is to exit the program and restart it. That gets you back to a small file that then can be edited until it again gets too large to handle.

This is more an annoyance than anything. But it makes me wonder about the quality of the rest of the

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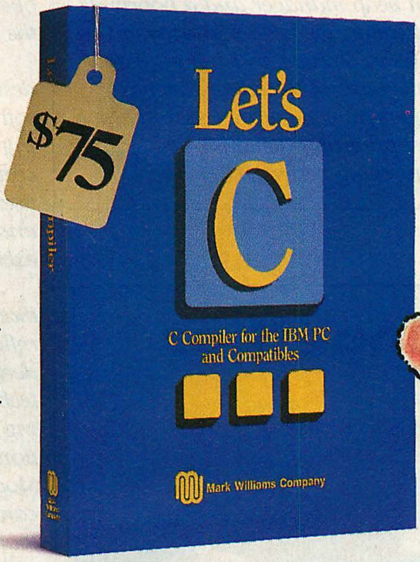

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code, and, in particular, about the accuracy of the code created by this compiler. I haven't junked Modula-2 yet, but I am looking forward to the arrival of Borland's Modula-2 system.

Peter J. Becker
Moscow, ID

Mr. Becker is correct in his description of the behavior of the MOD editor. The editor slowly consumes free memory during its operation. Any user can verify this by pressing Alt-F1, which reveals the current amount of free memory. The compiler needs at least 56KB free to run. If it does not have enough memory, it usually will complain about a heap or stack overflow.

To distinguish between a poorly written heap manager and a poorly designed editor, the heap management modules in Storage, which presumably form the basis of the editor's memory management code, were tested again. The test programs demonstrated Storage to be working perfectly.

After the review was written, I too ran out of memory once and MOD terminated most ungracefully, leaving behind a significant amount of work unsaved. Logitech admits that the fault lies with the MOD editor and has developed a fix, which will be included in the next release of the product.

This style of memory management design is not unique to MOD. Microsoft's Word also consumes memory during its operation. But Word's memory consumption is inapparent, because the user has no way to track free memory and does not know that the resource is exhausted until Word tells him to SAVE.

I would counsel against implying that the inadequate design of an editor reflects on the correctness of the underlying generated code. I find the Logitech code to be reasonably good, lacking only in the high degree of optimization found in some C compilers. As for Modula-2 from Borland, no forecast can be made regarding the debut of that product for the IBM PC.

—John T. Cockerham

ON THE RIGHT TRACK

Thank you for your thorough review of nine-track tape subsystems in the August 1986 issue ("Nine-track Tape Systems," Roger Addelson, p. 94). We at Overland Data feel that our tape subsystem was given a fair appraisal and was shown as the fine product that it is.

Mr. Addelson pointed out correctly that our tape archive program lacked an archival-select option, and that our data interchange software did not support labeled tapes. At the time of the product's review, this was true.

Since that time, Overland Data has released FLASHBAK, a new backup product for our nine-track tape subsystem package. In additon to a window-oriented interface, it features an archival-select option. FLASHBAK also offers a tree display of the DOS hard-disk file system, file-oriented backup and retrieval, and various selection and deselection criteria for backup and restore. It supports multivolume tapes and provides copy and remove functions for general file system support.

We also are releasing an enhanced data interchange program that supports labeled tapes and configuration translation tables. This program also allows record and field manipulations.

Since the review we also have enhanced our XENIX tape package to support the Berkeley IOCTL extensions. This feature allows XENIX programmers to write customized tape utilities when

they require enhancements to the standard XENIX tape commands.

Bob Long, president
Overland Data, Inc.
San Diego, CA

I am writing to address some oversights in Roger Addelson's review of Emerald Systems' one-half-inch, nine-track, micro-to-mainframe package.

First, our Tape Import/Export (TIE) software package requirement for using a record structure file is designed for use as an application package. The capabilities of this conversion tool extend far beyond mere EBCDIC/ASCII translation and can be used on disk-to-disk transfers as well. In addition, if one were to use no record format specification at all, the incoming tape data will become a continuous file suitable for the standard hashing algorithms used in many high-level language compilers. This important flexibility, and direct portability to comma-separated-variable (CSV) format for dBASE, Lotus 1-2-3, and other popular packages, turn the TIE "limitations" (to use the reviewer's word) into one-of-a-kind features that enhance actual intended usage of a nine-track subsystem.

Second, Emerald is and always has been fully compatible with all Novell networks, backing up or restoring all Novell files, including hidden, system, and read-only, while users are logged into the network. We also maintain security/trustee integrity for directories, user, and bindery files (Novell system security files), saving the network administrator time usually spent recreating the LOGIN IDs and user default environment after a severe disk crash or failure. Emerald does not use NetWare's LARCHIVE/LRESTORE standard interface, thus, we are able to back up and restore between network and non-network (stand-alone DOS) systems. Novell has certified our ASP backup/restore software for compatibility and has purchased our nine-track unit for its in-house conversion needs.

Third, Emerald does provide an installable device driver, documented for the serious user. The documentation also contains a complete C language #INCLUDE library of all tape functions.

Finally, no mention was made of our conversion speed of 3.3MB per minute (three times faster than the competition due to the use of dual DMA channels, and buffer allocation). Nor did the author mention that our interrupt request line and DMA channel are completely software-selectable, requiring the user to configure the controller only if a nonstandard I/O port address is required.

Michael A. Bollinger
Emerald Systems Corporation
San Diego, CA

UTILITY WORK

This letter is in response to the review of "The Nibbler" that appeared in the July 1986 issue (Product Watch, Tom Swan, p. 167). We at Tachyon were disappointed by the overall negative tone of the review, and we do not understand why the reviewer chose to dwell on many of the product's least important features while overlooking many of the more useful operations.

First, the term "bug-ridden" is used to refer to what are later described as two errors and some complaints about the program's design. Bugs usually denote some failure to operate correctly. Although The Nibbler most likely has its share of the pesky critters, the only real *bugs* mentioned were with the File Map that hung on the file IBMBIO.COM only on the master diskette, and a p-System copy function that had already been corrected in the latest version (2.2).

In the third paragraph, Mr. Swan lists many of The Nibbler's features but ignores perhaps the most useful and speedy asset. I find the file, disk, and memory search functions to be extremely handy. It is unfortunate that these were not mentioned. Also overlooked were the two versions of the program that load and run at opposite ends of a machine's available memory. This feature allows the user to access data in either low or high memory without overwriting it.

The Nibbler's on-line help is extensive enough that we contemplated not producing a manual. Mr. Swan's point about the index, or lack of it, is well taken, and an index will be added. I also agree that the ability to label disks is awkward. But since DOS 3.x offers a command to label disks, Tachyon turned its attention to implementing other features that seemed more critical. I do wonder why most of a paragraph was spent pointing out such a small and trivial grievance.

Later, The Nibbler is deemed "unacceptable" because it hangs when attempting to map the IBMBIO.COM and IBMDOS.COM files on the master diskette. If the instructions had been followed for installing a bootable DOS system on The Nibbler diskette, there would not have been a problem with the File Map. (These files do not actu-

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NEW FORM LAYOUT UTILITY simplifies form design.

ally exist until the installation program SETUP.BAT is run.) The File Map command will work correctly with any file on a diskette that has its file allocation table (FAT) links intact. I do not feel this is "unacceptable."

The Nibbler was undergoing development during the time of the review. This did cause us to delay several times in sending update review copies. This unfortunately came across as unreliable technical support. Perhaps some future version of The Nibbler will merit a further and more positive review.

A final note, The Nibbler and one other Tachyon product, a screen generator and menu manager called ScreenPro, have been licensed to Olympus Software in San Diego from where they will be marketed nationally.

Steven Blake, president
Tachyon Corporation
San Diego, CA

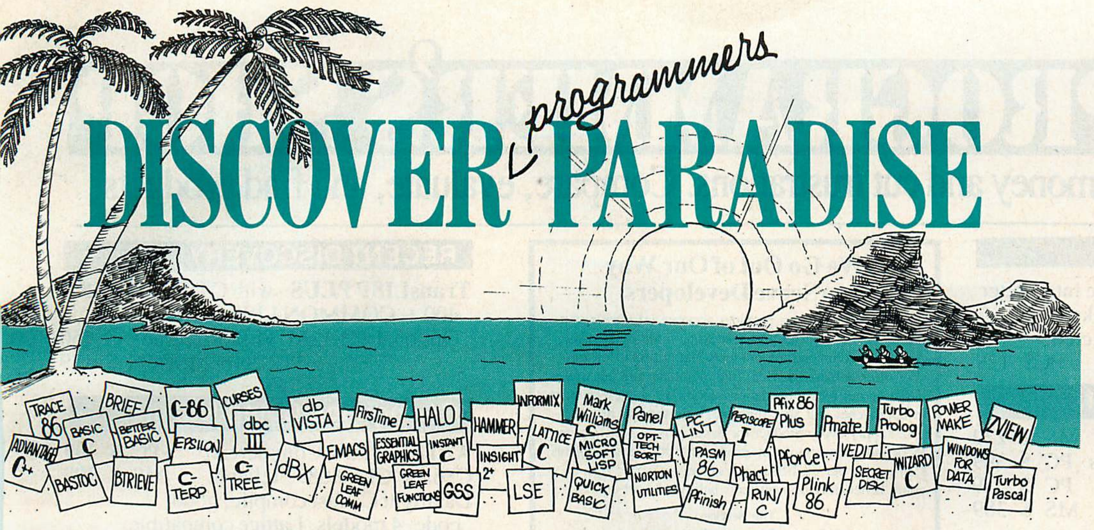
I appreciate that many products may undergo revisions after they have been reviewed. But I can review only what companies choose to send me. From all appearances, the version of The Nibbler that I received was a finished product. If this was not the case, Tachyon should have made that fact clear.

My criticism of the program for hanging while mapping IBMBIO.COM and IBMDOS.COM stands. I can accept no defense of a program—especially a programming utility—that causes my computer to crash. If Tachyon is aware of the cause of this problem, why doesn't it insert programming to prevent its occurrence?

—Tom Swan

ERRATA

The program PRF.ASM (listing 2), published with the article "An Execution Profiler for the PC" (Ralph G. Brickner, November 1986, p. 120), assembles correctly using version 4.0 of the Microsoft Macro Assembler (MASM); however, some older versions (including IBM MASM 2.0) will indicate phase errors when assembling this program. This can be remedied by replacing MOV DS:[20H], OFFSET NEW_TIMER in the procedure REPLACE_TIMER with MOV WORD PTR DS:[20H], OFFSET NEW_TIMER. During the first phase of assembly, IBM MASM reserves only one byte in the MOV instruction for the offset of the forward referenced label NEW_TIMER. During the second phase, two bytes are used for this value, thus changing the location of the next label and causing a phase error.



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NEW Products

386|ASM/LINK—Complete development package for 80386 microprocessor including an assembler, linker, and debugger. Upwardly compatible with Microsoft's Macro Assembler.
List $495 Ours **CALL**

LATTICE C—Version 3.2—Features full support for Microsoft Windows including the "Far," "Near," and "Pascal" key words.
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MICRO/SPF	175	CALL
OPT-TECH SORT	149	115
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RM/COBOL	950	639
RM/COBOL 8X	1250	895
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ACS TIMES SERIES	495	419
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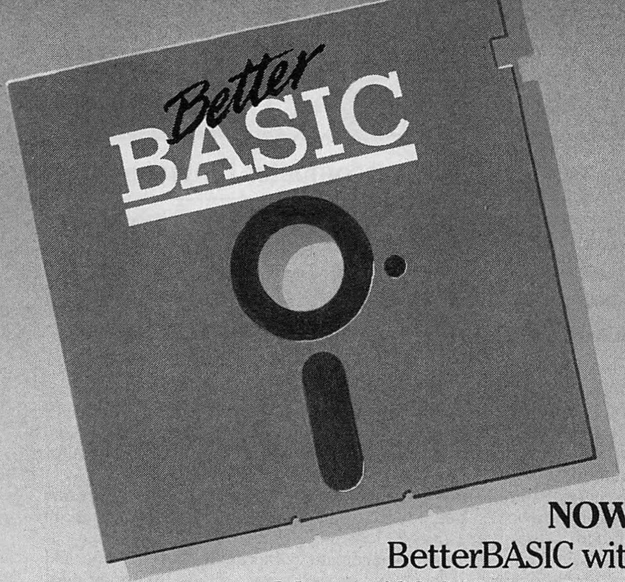

Better BASIC

NOW INTRODUCING VIRTUAL MEMORY SUPPORT

BetterBASIC with the optional Virtual Memory Manager can now address 400,000,000,000 bytes of memory!

BetterBASIC Application Development System — $199.00

The BetterBASIC Application Development System provides very close compatibility with PC-BASICA and GW-BASIC, yet provides numerous new and sophisticated language features such as: program Block Structures, recursive Procedures and Functions with local variables, structures, Records and Pointers and last but not least support of large memory.

Virtual Memory Manager — $99.00

The Virtual Memory Manager expands BetterBASIC's data space into the giga-byte range and finally breaks the 640k byte barrier for array sizes. Not only can you directly address all expanded memory supported by LIM/EMS memory boards, you can also address any RAM Disk, Hard Disk or even a Floppy Disk as if they were ordinary RAM.

Virtual Memory Manager-Network Version — $250.00

This version of the Virtual Memory Manager allows Virtual Memory to be distributed throughout a Local Area Network. It also provides File, Records and Field Locking to control access to shared data.

C-Link — $99.00

This software package allows BetterBASIC to access C-language library functions from within BetterBASIC. Currently supported are Lattice and Microsoft C.

Screen Design System — $199.00

This package truly takes the drudgery out of creating display screens and data entry screens. An interactive Screen Editor lets you "paint" your display screens exactly as you want them to appear in your program. The completed screens take the form of disk resident images. A run time library module provides many new BetterBASIC procedures and functions for interacting with the display screens to simplify the use of pop-up menus and data entry screens.

Btrieve™ Interface — $99.00

This is a high level BetterBASIC interface to the ever popular Btrieve™ file manager from SoftCraft. Instead of Assembly language calls this module provides high level BetterBASIC program access to all Btrieve™ functions. Use it to design your own database application in BetterBASIC.

8087/80287 Math Module — $99.00

This module allows you to use the 8087 or 80287 co-processor to significantly accelerate programs which are floating point calculation intensive.

Decimal Math Module — $99.00

If you are a business programmer, you are probably frustrated by the many roundoff problems caused by ordinary IEEE format floating point numerical operations. The BetterBASIC Decimal Math Module which offers variable precision from 6 to 24 digits, drastically reduces roundoff problems in business applications.

BetterTools™ — $99.00

This is a collection of more than 150 useful extensions to BetterBASIC such as time and date computations, encryption and decryption, low level file directory access, hyperbolic function and much more. No BetterBASIC programmer should be without BetterTools™.

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SPECIFICATIONS

BetterBASIC is GW-BASIC and PC-BASICA compatible; runs on IBM PC and compatibles.

HARDWARE REQUIREMENTS

CPU: IBM PC, IBM PC XT AT, COMPAQ, IBM PC Compatibles
Memory: 256KB min up to 640KB
Display: Monochrome or Color
Disk Drive: One 5¼″ floppy, single or double sided
Operating Systems: MS-DOS 2.0, 2.1, 3.0, 3.1

DATA TYPES:

Numeric Data:
- BYTE, range: 0 to +255
- INTEGER, range: − 32768 to + 32767
- REAL, range: Single Precision $8.43x10^{-37}$ to $3.37x10^{38}$
  Double precision $4.19x10^{-307}$ to $1.67x10^{308}$
- Binary Math, Single/Double/Mixed Precision
- Mixed mode numeric expressions will always be REAL.

String data:
- Variable from 0 to 32767 characters in size.

Record Variables:
- Allows grouping of dissimilar data types into a single logical variable. Elements of a RECORD are addressed as FIELDS and can be of any type, including ARRAY, RECORD and POINTER.

Array Variables:
- N-dimensional arrays of any type, including ARRAY, RECORD and POINTER. Dynamic arrays like PC-BASICA

Pointer Variables:
- Allows indirect reference to any data type. Can be used with RECORD variable to create linked lists, or to create relational data structures.

In addition supports PC-BASICA record types.

BetterBASIC BENCHMARK COMPARISON
in milliseconds

	Better BASIC			IBM INTERPRETIVE		IBM COMPILED	
	SP*	DP*	8087 DP	SP	DP	SP	DP
REAL FOR/NEXT	1.3	1.4	0.55	0.93	0.93	0.7	0.7
ASSIGNMENT	1.0	1.0	0.93	1.5	1.5	0.1	0.1
ADD	0.77	1.1	0.44	1.6	2.3	0.4	0.4
MULTIPLY	0.88	1.8	0.49	1.9	3.0	0.5	0.8
DIVISION	1.0	3.0	0.49	2.8	19.7	0.6	1.1
LOGARITHM	5.7	15.6	0.55	7.5	64.0	4.0	11.9
EXPONENTIAL	7.4	27.0	0.66	6.5	43.0	3.6	10.8
SINE	4.7	17.0	0.82	17.6	35.0	3.2	12.4
COSINE	4.5	17.0	0.77	25.0	41.0	3.5	12.7
TANGENT	7.2	18.0	0.66	44.0	94.0	6.9	26.0
X^Y	13.8	44.5	1.1	15.2	115.0	7.7	24.0
SQR (SQUARE ROOT)	1.4	6.5	0.33	7.2	95.0	1.1	3.5

*SP = Single Precision
DP = Double Precision

ADDITIONAL BetterBASIC STATEMENTS

ANY ARG
APPEND
ASH
ASSIGN
AUTODEF
BIN$
BREAK
BREAK OFF
BYE
BYT
BYTE
BYTE ARG
BYTE ARRAY
BYTE ARRAY ARG
BYTE ARRAY PTR
BYTE ARRAY STRUC
BYTE PTR
CHANGE
CHAR$
CHECK
CLD
CLW
CODE
COLOR BORDER
COMMAND$
COMPRESS
CONSTANT
DEFINE WINDOW
DEL$
DIR$
DISABLE
DO
DO IF
DO UNTIL
DO X TIMES
DRIVE$
DYNAMIC
END DO
END FUNCTION
END PROCEDURE
ENDPROC
ERRORMODE
EXIT
EXIT GOSUB
EXIT X LEVELS
EXTERNAL
FRAME
FRAME WINDOW
FREEDISK
GOTO END
HEADER
INPUT FROM
INS$
INTEGER
INTEGER ARG
INTEGER ARRAY
INTEGER ARRAY ARG
INTEGER ARRAY PTR
INTEGER ARRAY STRUC
INTEGER FUNCTION
INTEGER PTR
INTERRUPT
INTERRUPT CLEAR
INTERRUPT ON/OFF
INTERRUPT PROC
INTERRUPT RESTORE
INTERRUPT SAVE
INTR
KEY=
KEYWORD ARG
KEYWORD SET
LIST ALL
MAIN
MAKE MODULE
MAKE PROGRAM
MAX
MAX$
MEM
MIN
MIN$
MODULES=
OFFSET
ON INTERRUPT
PRECISION=
PRINT TO
PRINT TO USING
PROCEDURE
PROCS=
PUBLIC
READ RECORD
READCHR
READCHR FROM
READLINE
READLINE FROM
READ RECORD
REAL
REAL ARG
REAL ARRAY
REAL ARRAY ARG
REAL ARRAY STRUC
REAL FUNCTION
REAL PTR
RENAME
REPEAT
RESTART
RESTORE PAR
RESTORE SCREEN
RESULT=
RETRY
ROT
SAVE MODULE
SAVE PAR
SAVE SCREEN
SCOPE=
SCRATCH
SEG
SELECT
SET
SET CURSOR
SH
SHELL
SIZE
SIZE$=
SPAN
STACK=
STATUS=
STATUSLINE
STRING
STRING ARG
STRING ARRAY
STRING ARRAY ARG
STRING ARRAY PTR
STRING ARRAY STRUC
STRING FUNCTION
STRING PTR
STRUCTURE
SYSCALL
SYSCODE
SYSFLAGS
TYPE
UPPER$
WHILE . . . DO
WINDOW
WOR
WRITE RECORD
WRITE TO
XMEM
XMEM=
XREF

Microsoft Statements Not Supported

DEF USR
MERGE
MOTOR
ON PEN
ON STRIG
PEN
STICK
STRIG
USR

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Compaq Deskpro 386

Compaq calls it the third major milestone in the history of personal computers; this may be more than pure hype.

The IBM PC standard is pervasive in the industry. It has exceeded all expectations, including those of IBM. Now, with the creation of a new generation of microprocessors in the Intel 80386, an evolution of the standard is possible. Not content to stand by and wait until IBM decided to lead the industry into the next stage, Compaq Computer Corporation has forged ahead with the development of the Deskpro 386. The PC standard is no longer IBM's exclusively.

In recognition of Compaq's foresight and initiative, *PC Tech Journal* has named the Compaq Deskpro 386 as its Product of the Year for 1986.

Since 1983, Compaq has regularly demonstrated its ability to compete with IBM. Compaq is *not* noted for being a cheap clone manufacturer; the company has always produced a quality machine that sells for a premium price. Compaq has managed to continue its growth throughout the shake-ups that caused many manufacturers of compatibles to collapse. It not only is clearly established as the largest manufacturer of compatibles, but is now offering itself as a pacesetter as well.

Compaq's president and CEO, Rod Canion, calls the announcement of the Deskpro 386 the third major milestone in the history of personal computer technology—following the arrival of the Apple II and the introduction of the IBM PC. This statement represents a corporate confidence that probably would not be accepted from a company any less respected than Compaq.

The unveiling of the Deskpro 386 on September 9 was especially noteworthy in that this was not a machine to be produced sometime in the future, but was available the day it was announced. (*PC Tech Journal* was able to use and ultimately buy the machine for testing in its own laboratory.) Further, Compaq's announcement was accompanied by a statement of immediate support by industry leaders for the development of hardware and software.

The Deskpro 386 offers compatibility with previous standards and allows a growth path to the future. The machine's success will not be due to any dramatic technological breakthroughs, but will be because all aspects of the current standard were examined and incorporated. This machine provides the new technology while retaining the old.

Many issues of compatibility must be considered in designing an IBM-compatible machine, and Compaq has achieved excellence by attending to these issues—at considerable expense. Throughout its development as a company, Compaq has devoted substantial in-house resources to testing all versions of Compaq machines and upgrades with all of the commonly available software and add-on devices.

One example of Compaq's fanatical zeal for compatibility is in its support of the IBM Token-Ring Adapter. IBM's own XT-286 requires a software patch to support the Token-Ring, but the Deskpro 386 has this support built in.

The Compaq BIOS has always been compatible and has kept pace with the evolution of the standard from its first introduction to the latest version. Compaq designs its own BIOS rather than buying it from a third party; this, together with its in-house research, gives the company a control over updates that is unmatched in the industry.

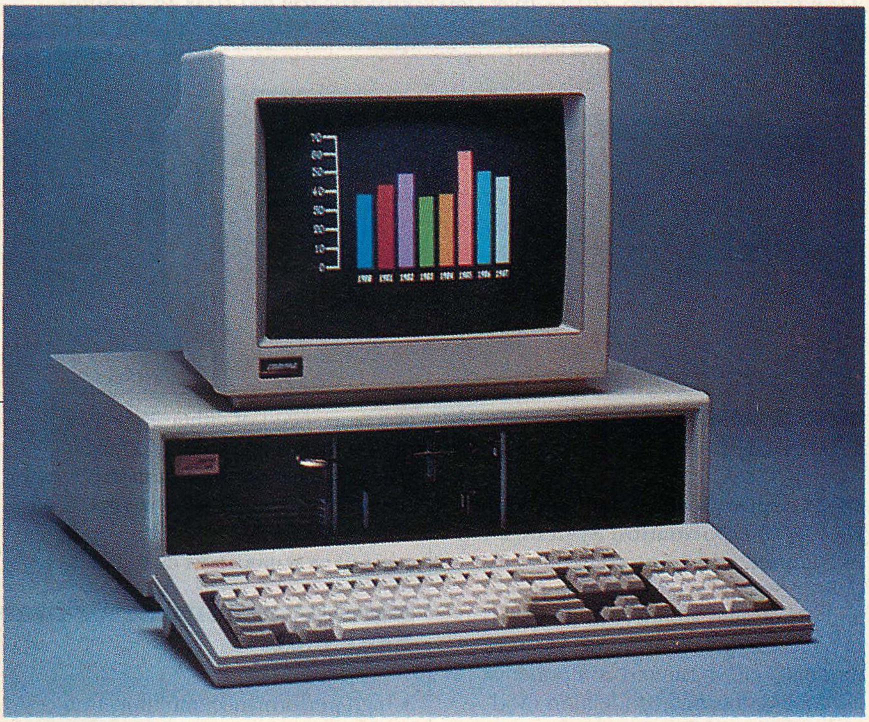
Through its series on AT compatibles, *PC Tech Journal* has become quite familiar with the subtle incompatibilities that can appear when testing computers. The Evaluation Suite designed for the series, "Out from the Shadow of IBM. . .," (Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52) provides ample opportunity for incompatibilities to appear. To date, the Deskpro 386 that is being evaluated for an upcoming article has displayed no signs of nonconformance with the standards.

A strong company might be tempted to exploit all of the new features in a new microprocessor, encouraging the rest of the industry to drop its existing standards. Compaq, however, decided that its name was not strong enough to do this, and the state of the supporting technologies for the machine is such that the 80386 cannot be used to its full potential yet.

Compaq has made use of the state of the art where appropriate—for example, in its 32-bit memory system. Memory is the only current technology that allows the use of the 80386's 32-bit features. Compaq elected to maintain the 8-MHz AT bus and make the memory system interface proprietary by using a separate bus instead of setting a 32-bit-bus standard for the industry. Although criticized for not taking the standard further, Compaq opted to retain a measure of security. Its choice assures that the existing machine will be compatible with any future IBM design that includes the existing standards, yet it provides a good migration path for power-hungry users who are clamoring for more, right *now*.

Although a new standard has not been set, Compaq has used the available memory in a novel manner. The 1MB of 32-bit memory that is supplied with the machine is used in the conventional manner for the first 640KB of memory, and the last 360KB is mapped into the area of memory immediately below the 16MB point. The system ROM BIOS and EGA BIOS are copied into this area, allowing all BIOS calls to be accessed at 16 MHz, 32 bits at a time. This is beneficial to EGA applications that use the BIOS calls and do not write directly to the screen.

Reasoning that no need exists for a 32-bit bus at this time, Compaq made the decision to put a 16-bit bus in the Deskpro 386 and run it at 8 MHz—an interim, but valid, solution. The 8-MHz bus is an example of the typically con-



servative nature of Compaq. The problem with simply boosting the speed of a machine, as many have done with the 12-MHz AT compatibles, is that the add-on boards do not work reliably on a 12-MHz bus. The add-on board manufacturers are not likely to change their designs to regain compatibility for the compatible manufacturers. Expecting the rest of the industry to redesign product lines is not a realistic solution. Tests run by *PC Tech Journal* indicate that the currently available add-on boards and peripherals appear to work acceptably only up to speeds of about 9 MHz. Therefore, the 8-MHz bus offered by Compaq does not present any compatibility problems.

Compaq, however, has gone a step further. In order to deal with the programs that require the speed of the disk drive to be controlled by an 8-MHz microprocessor (typically, those programs with a copy protection system that is based on timed parameters), Compaq has designed the Deskpro 386 so that it automatically slows down whenever drive A: is accessed, allowing all bootable disks that work on the 8-MHz AT to function correctly. This can be overridden by setting a MODE command.

Compaq's accommodation of existing standards is even more comprehensive. The speed of the processor, as seen by the application that is currently running in the machine, can be adjusted from 4.77 to 16 MHz. Rather than changing the CPU clock speed, the memory refresh cycle is extended. This is done by putting the microprocessor into the hold state for a preset period of time, thus achieving compatibility with even the most obscure program. This design, which illustrates the company's attention to detail, is a sophisticated implementation that ensures that direct memory accesses to the bus are not excessively delayed.

The hard disks used in the Deskpro 386 are state of the art but do not necessitate a faster bus. The 140MB drive has an average access time of 19 milliseconds (ms), and even the base system has a very respectable 25-ms typical access time for a 40MB disk. Given the current state of the technology, this speed and that of the disk controller are too slow to benefit from a 32-bit bus, but they are the best currently available for a reasonable cost.

No existing graphics standards for the microcomputer market use a 32-bit architecture. The current state of the art is the EGA, an 8-bit based system. After considering the various paths that the standard may take, Compaq concluded that in all likelihood the next generation of graphics systems would be based on graphics processors such as the 82786 from Intel or the TMS34010 from Texas Instruments. Currently, predicting which system will become the new standard is impossible.

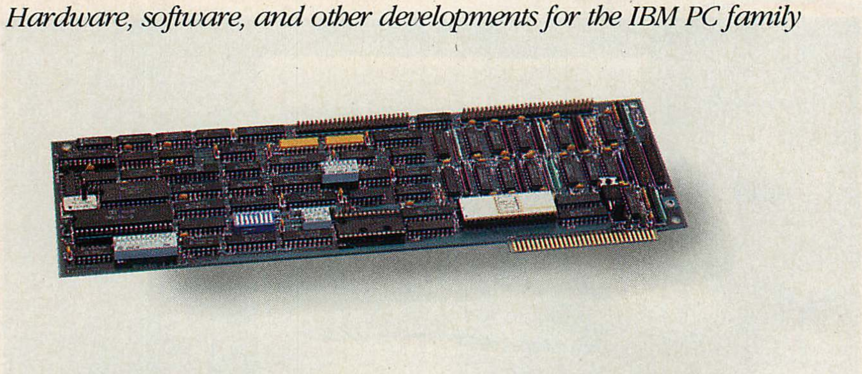
Although Compaq could have designed a 16-bit EGA to use existing standards, this probably would not be a worthwhile development in light of the 32-bit processor. Compaq, however, does make the existing standard work in the best way possible. It is to be commended for its innovative method of copying the ROM BIOS on the EGA card into the RAM, taking the information 32 bits at a time instead of 8, and accessing this data at 16 MHz.

The industry seems to believe that Compaq has made the right decisions and is leading the way into the future of the 80386. Companies providing support for the Deskpro 386 with existing products include Ashton-Tate with dBASE III PLUS, AST Research with its Advantage! board, Hayes Microcomputer Products with its Smartmodem series, Lotus Development Corporation with 1-2-3, and Microsoft with Word. Microsoft also has announced XENIX System V/386, the first general-purpose operating system to take advantage of the 32-bit architecture of the 80386.

While other companies have announced 80386-based machines, none appears to have considered the full implications of the existing standard, and none has provided a means to reach new and better goals. Compaq offers compatibility for the present by using the 80386 in the AT-compatible mode, but it leaves room for progress as operating systems and applications that exploit the new processor are developed and become the new standard. The Deskpro 386 is a fine example of how Compaq can shape the industry with an existing standard that is bigger than originally conceived and by offering solutions for the future.

Compaq Deskpro 386
Model 40: $6,499
Model 130: $8,799
Compaq Computer Corporation
20555 FM 149
Houston, TX 77070
713/370-0670
CIRCLE 364 ON READER SERVICE CARD

Hardware, software, and other developments for the IBM PC family



DC-8000 multifunction controller from Wespercorp

IBM 9370 Model 20 entry-level information system

FROM IBM

IBM Corporation has announced the **IBM 9370 Information System**, a line of compact, mid-range computers that deliver System/370 processing power and mainframe architecture in the space of a file cabinet. Four models feature modular, rack-mounted components; air-cooled, thermal conduction modules; IBM's 1-million-bit-chip memory technology; and dense logic-circuitry packaging. The wide range of existing System/370 teleprocessing, networking, and communications systems management capabilities is augmented by the new IBM 9370 integrated controllers and LAN support. All processors in the 9370 Information System have a maximum memory capacity of 16MB. External storage is provided by the current rack-mounted IBM 9332 direct access storage device (DASD) with a maximum storage capacity of 400MB and by the current IBM 9335 DASD with 800MB. From $31,000 for Model 20 with 4MB to $210,000 for Model 90 with 16MB.

The **IBM 9347 Magnetic Tape Drive** is rack-mounted and uses standard one-half-inch tape to provide backup, recovery, and interchange of data in streaming mode at 1,600 bits per inch. The IBM 9347 records data at a tape speed of either 25 inches or 100 inches per second. $7,900.
IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573; 800/426-2468
CIRCLE 311 ON READER SERVICE CARD

IBM 9347 Magnetic Tape Drive

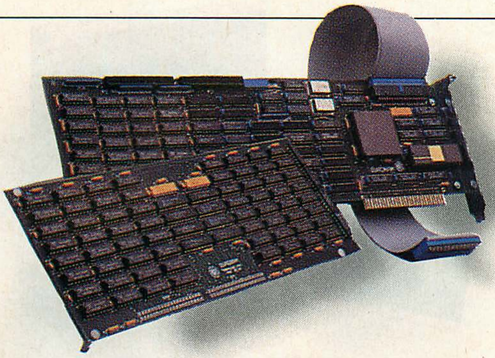
HARDWARE

A high-performance, multifunction controller for the PC, PC/XT, PC/AT, RT PC, and compatibles has been announced by **Wespercorp**. The **DC-8000** multifunction controller combines an SMD controller with a small computer system interface (SCSI) host adapter on a single, standard-sized PC board. Intended for the OEM market, the DC-8000 allows the systems integrator to configure a PC with up to two high-performance SMD disk drives and to integrate as many as eight SCSI-compatible tape or laser optical drives and other peripherals. Some of the features that are supported by the DC-8000 include: overlapped seeks, 32-bit error-correcting code (ECC) with 11-bit error correction, variable sector interleaving, and media-defect mapping by sector. $1,715.
Wespercorp, 1821 E. Dyer Road, Santa Ana, CA 92705; 714/261-0606
CIRCLE 323 ON READER SERVICE CARD

The **MotherCard 5.0** from **SOTA Technology, Inc**. turns a PC into a PC/AT-compatible computer. The MotherCard is a full 80286-based computer on a full-length board that plugs into a PC expansion slot. The MotherCard has an 80286 (8- or 10-MHz) microprocessor and comes standard with 640KB of DOS memory, 320KB of expanded memory, a realtime clock, and a socket for the 80287 (5-, 8-, or 10-MHz) numeric coprocessor. A daughterboard connector allows later expansion to 16MB of memory. The 8088 on the PC motherboard is removed and plugged into a socket on the MotherCard. A cable then runs from the empty 8088 socket on the motherboard to the MotherCard. The user can switch back to 8088 by entering a simple, DOS-level command. When in the 80286 mode, all software programs are executed from the fast zero- or one-wait-state DRAM. $995.
SOTA Technology, Inc., 657 N. Pastoria Blvd., Sunnyvale, CA 94086; 408/245-3366
CIRCLE 320 ON READER SERVICE CARD

American Computer & Peripheral, Inc. has announced the **386 TURBO**, an accelerator card that uses the Intel 80386 to bring a 6-MHz PC/AT up to 12-MHz speed and an 8-MHz AT up to 16-MHz. Clock rates are switchable via software without a system reboot. The 386 TURBO has a 1MB cache memory with a 100-percent cache hit rate. The cache memory responds to all write operations in the lower megabyte of the system memory map. Read operations from cache memory may be enabled or disabled through software in three memory segments: main, video, and ROM BIOS. $1,995.
American Computer and Peripheral, Inc., 2720 Croddy Way, Santa Ana, CA 92704; 714/545-2004
CIRCLE 313 ON READER SERVICE CARD

Chips and Technologies, Inc. has introduced the seven-chip **CS 8230 AT/386 CHIPset** for Intel 80386-based, 32-bit microcomputers. The CHIPset, combined with the recently introduced **82C206 Integrated Peripherals Controller** (IPC) chip, lets users configure a PC/AT-compatible system board with a total of 40 chips, plus memory. The seven chips include one bus controller chip, one page/interleave memory controller chip, two address buffer chips, two data buffer chips, and one miscellaneous control logic chip. Also announced was a development kit for the AT/386 CHIPset, **DK 8230**, which includes a development board, a data



Quadram's Quad386 XT enhancement board for the PC/XT

PC/AT-compatible Premium/286 from AST Research, Inc.

sheet, a user's guide, and data book for the CS 8230 CHIPset. CS 8230 CHIPset, $196.40; 82C206 IPC, $49.00; DK 8230 Development Kit, $2,995.00.
Chips and Technologies, Inc., 521 Cottonwood Drive, Milpitas, CA 95035; 408/434-0600
CIRCLE 314 ON READER SERVICE CARD

Quadram Corporation has announced an enhancement board that delivers the power and functionality of the 80386 to the PC/XT. The **Quad386 XT** occupies a single slot in the XT and features an 80386 16-MHz microprocessor, 1MB of true 32-bit memory using 256KB DRAM, and 2MB of memory upgrade on an optional daughterboard. The Quad386 XT also provides on-board support for an 80287 numeric coprocessor, 96KB of image memory, and 32KB of direct cache memory. $1,495.
Quadram Corporation, One Quad Way, Norcross, GA 30093; 404/923-6666
CIRCLE 315 ON READER SERVICE CARD

A 16-MHz, 80386-based, PC/AT-compatible system, designed for the OEM market, has been announced by **Future International, Inc.** The **XA-600** will address up to 16MB of RAM and can move between operating systems such as UNIX and DOS. The XA-600 is available as either a low-profile, four-slot/four-drive desktop version or as an eight-slot/six-drive standing configuration. Both allow memory expansion via daughterboards. Standard features include 4MB of RAM on the system board (expandable to 16MB); 1.2MB diskette drives; 40MB, 60MB, 80MB, and 130MB hard-disk options; and optional tape backup. The available display monitor options include 12-inch monochrome, 15-inch black-and-white, and 14-inch color. Under $2,500 in OEM quantities.
Future International, Inc., 5820 Stoneridge Mall Road, Suite 100, Pleasanton, CA 94566; 415/847-2064
CIRCLE 318 ON READER SERVICE CARD

A family of 80286-based microcomputers, **Premium/286**, has been announced by **AST Research, Inc.** All of the models are PC/AT-compatible and come equipped with a 1.2MB diskette drive, a 101-key enhanced keyboard, a combination diskette/hard-disk controller, and a 25-pin, RS-232 asynchronous serial port and parallel printer port. The operating speeds of 6, 8, or 10 MHz are visible in an LED display on the front panel of the CPU and are user selected by a keystroke sequence. With a total of seven slots, the Premium/286 incorporates two special AST FASTslots, which can run without wait states at any of the machine's speeds. These AST FASTslots can be upgraded in the future to accommodate the next generation of microprocessor cards.

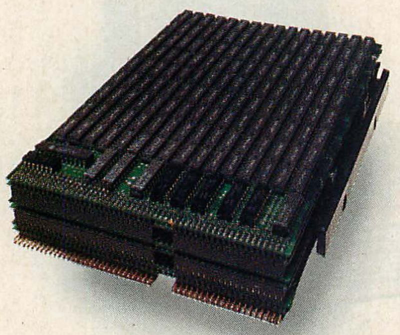
The Premium/286 machines accommodate as many as four drives, with three half-height drives accessible from the front panel. Each model is equipped with either 512KB or 1MB of FASTRAM, which can be configured as expanded (including AST enhanced expanded memory), extended, or conventional memory. All models, except one, include a multimode graphics card that supports graphics modes for the Enhanced Graphics Adapter, Color Graphics Adapter, Hercules Graphics Card, and Monochrome Display and Printer Adapter. AST monochrome and enhanced graphics monitors are optional. From $1,995 to $3,995.
AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714-4992; 714/863-1333
CIRCLE 312 ON READER SERVICE CARD

All Aboard 286, the latest surface-mount-technology board from **IDEAssociates, Inc.**, can address the maximum 16MB memory of the PC/XT-286 and PC/AT through the use of 1MB RAM chips; it fits them onto one board using single in-line memory modules (SIMM). These space-saving chip packs are mounted vertically to the board's surface. Also included are serial and parallel ports and EGA, CGA, and monochrome capabilities. The board may be configured with up to 4MB of memory using conventional 256KB chips. This memory may beused as conventional, expanded, or extended memory. 128KB, $995; 4MB, $2,595; 16MB, $12,995.
IDEAssociates, Inc., 29 Dunham Road, Billerica, MA 01821; 617/663-6878
CIRCLE 316 ON READER SERVICE CARD

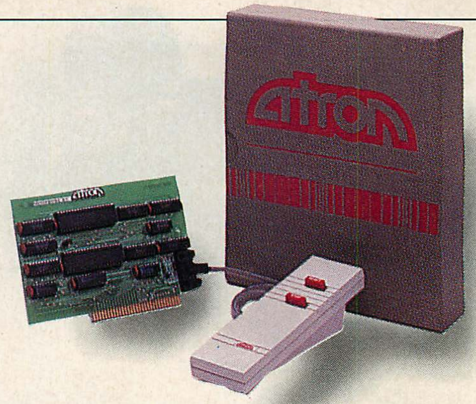
Designed to meet the size specifications of the PC/XT-286, **TurboRAM** by **CSS Laboratories, Inc.** is a 16-bit memory expansion card that can be upgraded to 2MB. TurboRAM supports a clock speed of up to 10 MHz. The expanded memory function is provided by the TurboRAM software. 0KB, $230.
CSS Laboratories, Inc., 2134 S. Ritchey Street, Santa Ana, CA 92706; 714/540-4141
CIRCLE 321 ON READER SERVICE CARD

Asher Technologies has started shipping a minicomputer gateway. Consisting of a plug-in PC card and software, the **MiniLink Gateway** is based on the 16/32-bit Motorola 68000 processor. Compatible with standard NETBIOS software, the MiniLink Gateway is capable of distributing seven IBM System/3x sessions concurrently to PC users linked together via a LAN. $2,290.
Asher Technologies, 1009 Mansell Road, Suite I, Roswell, GA 30076; 800/334-9339; in Georgia, 404/993-4590
CIRCLE 322 ON READER SERVICE CARD

Data Crossing Corporation has announced an internal 1200-bps modem for the PC Convertible called the **LapTalk 1200C**. This modem offers full Hayes compatibility and a surge suppressor. The LapTalk 1200C consists of two boards: one modem board slides into a guide slot above the battery, another—the direct access arrangement—



DART, Newer Technology's internal memory system



MINIPROBE hardware-assisted debugger from Atron

is bolted next to it at the left rear of the unit. The surge suppressor, called **Shock Lock**, consists of an ordinary telephone cord with a pill-box bulge that houses the suppressor itself and attaches to the modem with RJ-11 clips. LapTalk, $435.00; Shock Lock, $49.95. *Data Crossing Corporation, 1405 Stevenson Drive, Suite 3-803, Springfield, IL 62703; 800/654-1390*

CIRCLE 319 ON READER SERVICE CARD

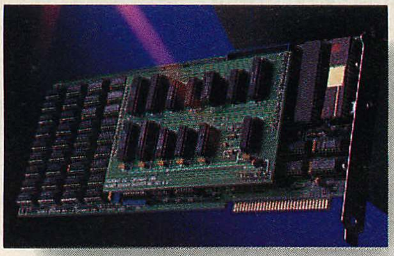
Newer Technology has introduced an internal, solid-state memory system for 8088-, 80286-, and 80386-based computers. **DART**, which is installed in a disk drive slot, provides either ultra-high capacity RAM expansion or high-speed mass storage. DART uses a modular, high-density semiconductor array to expand memory in increments of 8MB or 32MB within a single internal unit. Models range in capacity from 8MB to 192MB in 5¼-inch half- and full-height versions. Designed for low power consumption, DART eliminates the need for an internal cooling fan. Controllers are available in PC BUS-based (one slot add-in board) and small computer system interface (SCSI) bus (resides in DART) interface. Parity error correction is standard on all controllers. A transfer rate of 20MB per second is possible, limited principally by host bus bandwidth. 8MB module, $2,795; additional 8MB modules, $1,995 each. *Newer Technology, 251 Whittier, Wichita, KS 67207; 316/685-4904*

CIRCLE 329 ON READER SERVICE CARD

CMS has announced **new versions** of its add-on tape drives for the PC/XT-286 and Compaq 386. Available in 20MB and 60MB capacities, the drives are updates to the **Model T-120** and **Model T-160** external tape backup subsystems from CMS. Both drives use one-quarter-inch tape cartridges, adhere to the QIC data format, and feature a transfer rate of 90KB and a tape speed of 90 inches per second. The T-120 has four tracks, the T-160 has nine. The newer models come with a controller and menu-driven software. Each is housed in a compact cabinet with built-in power supply. T-120, $995; T-160, $1,595. *CMS, 3080-A Airway Avenue, Costa Mesa, CA 92626; 714/549-9111*

CIRCLE 324 ON READER SERVICE CARD

MicroWay, Inc. has announced an accelerator board that increases standard PC performance by a factor of 3.5. The **Number Smasher/ECM** can run at board speeds of 4.77, 9.54, or 12 MHz. Number Smasher/ECM comes with matched, factory-installed 8086 and 8087 processors and the 8087 test program. It is available with 512KB or 640KB of



Number Smasher/ECM accelerator board by MicroWay, Inc.

conventional memory with 1MB of extended memory. $599 to $1,199.

The **287TurboPLUS**, MicroWay's PC/AT accelerator board, generates an adjustable clock signal to boost the system clock of the AT, which increases the speed from 6 or 8 MHz up to 11.5 MHz in .5-MHz increments. The board plugs into the AT's 80287 socket and includes a hardware reset button. 10-MHz, $549; 12-MHz, $629; without 80287, $149; optional 10-MHz 80286, $175. *MicroWay, Inc., P.O. Box 79, Kingston, MA 02364; 617/746-7341*

CIRCLE 327 ON READER SERVICE CARD

Atron has produced a lower-cost, hardware-assisted debugger that plugs directly into the PC or PC/AT. The **MINIPROBE** has one realtime hardware breakpoint on reading or writing to memory, or a range of memory or I/O. MINIPROBE has a stop/reset switch box that lets the programmer regain control of the computer when it locks up. Support for Microsoft's CodeView and Atron's other debuggers is included. $395. *Atron, 20665 Fourth Street, Saratoga, CA 95070; 408/741-5900*

CIRCLE 317 ON READER SERVICE CARD

A plug-in card for the PC, PC/XT, and PC/AT that provides realtime in-circuit emulation of a ROM or EPROM of up to 64KB, with an average access time of 200 nanoseconds, is available from **Beck-Tech, Inc. ROMICE** is processor-independent and operates in 4-, 8-, 16-, or 32-bit microprocessor systems. DOS software is included to support a screen editor of the memory contents, hexadecimal file load and save, and 20 other utility commands. $595. *Beck-Tech, Inc., P.O. Box 5027, Berkeley, CA 94705-0027; 415/548-4054*

CIRCLE 326 ON READER SERVICE CARD

A 9600-bps modem for use on voice-grade, dial-up telephone circuits has been announced by **USRobotics, Inc.** The **Courier HST** (for high speed technology) provides full-duplex data communication through an asymmetrical frequency division of the telephone channel. At 9600 bps, the Courier HST uses 32-state Trellis Coded Modulation. A proprietary error-control and flow-control protocol allows error-free transmission of up to 1,100 characters per second. The Courier HST uses an extended version of the Hayes AT command set and works with most data communications software. The modem automatically falls back to 2400, 1200, and 300 bps in both answering and originating calls. $995. *USRobotics, Inc., 8100 N. McCormick Blvd., Skokie, IL 60076; 312/982-5010*

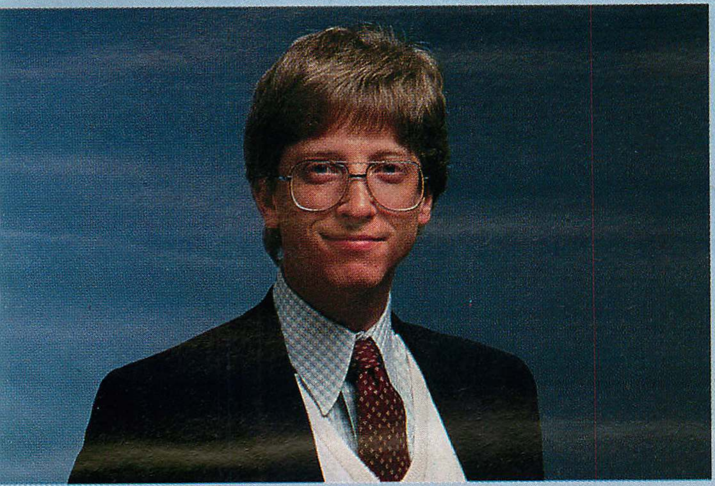
CIRCLE 328 ON READER SERVICE CARD

MICROSOFT LANGUAGES NEWSLETTER Vol. 2, No. 1

Dear Reader:

Imagine an integrated programmer's workstation running on a 386 with all the speed and memory you could ever dream of.

Think of what you could do with an integrated editor and an incremental compiler and linker that let you write and modify your programs with blazing speed. And an integrated debugger that maximizes your creativity by working with your language of choice, whether it's C, BASIC or perhaps some new language.



Imagine what would be possible if you could run programs through an optimizing compiler that produced small, tight code by performing optimizations throughout your procedures and beyond.

These visions from the future are behind the work we're doing today with Microsoft languages. You're already seeing the first steps toward these goals in several of our recent language products, such as Microsoft® C Compiler, Version 4.0, with the CodeView™ debugger, and Microsoft QuickBASIC Compiler, Version 2.0, with its integrated programming environment.

You'll continue to see us take more steps toward these visions over the years ahead. Creating the latest technology tools is essential to us at Microsoft, since we use these programming languages every day in our own development work.

A year ago we started the Microsoft Languages Newsletter to communicate these advances to you. But we hope we've been able to do a whole lot more by giving you programming tips on topics of interest to you. For example, we talked about mixed memory model dynamic allocation in the Microsoft C Compiler and using the mouse in Microsoft QuickBASIC programs.

Send in your suggestions on topics you'd like us to cover in future newsletters. And we'd also like to hear your vision of the ideal programming environment.

Establishing this two-way communication with you is important to us. Because hearing what you want is one of the key ways we make decisions that improve our language products.

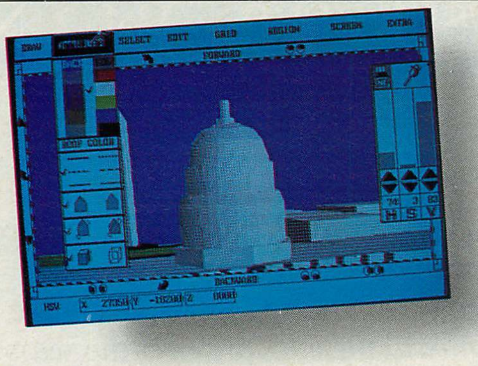
Thanks for sharing your ideas with us about our languages and our newsletter.

Sincerely,

Bill Gates

Bill Gates
Chairman of the Board
Microsoft Corporation

P.S. If you'd like to receive a complete set of newsletters from our first year, we'll be happy to send you one while supplies last. Just write us at: Microsoft Languages Newsletter, Dept. TJ, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717



Screen from Dynaperspective by Sun Grade, Inc.

Business Basic Extended (BB^x) from BASIS, Inc.

SOFTWARE

Dynaware, a division of **Sun Grade, Inc.**, has introduced **Dynaperspective**, a three-dimensional, solid-modeling graphics package. Dynaperspective combines line, shape, form, color, and shade to create complex renderings in two- and three-dimensional formats. The program is based on solid-surface modeling using hidden-surface functions, rather than wire-frame modeling. Thus, the user can perform quick perspective changes, apply surface color and shading, and create curved-surface models automatically either by defining axis points for 360-degree rotation or by freehand. Dynaperspective allows the user to present a rendering with fully-colored solid surfaces, transparent surfaces, or as simple line drawing. Renderings can be viewed from any perspective in seconds, once the initial compilation has taken place. $1,850.
Dynaware Division, Sun Grade, Inc., 1309 114th SE, Bellefield Building, Suite 316, Bellevue, WA 98004; 206/451-0200

CIRCLE 331 ON READER SERVICE CARD

Data Interface Systems Corporation has announced a software product that provides IBM 3270 cluster capabilities to workstations in a Novell LAN. Using the **DI3270 Micro/Mainframe Integration System**, a single PC serves as a gateway to an IBM mainframe host, emulating a 3274 controller and serving the communications needs of other PC workstations in the network. The gateway PC remains available for use as a workstation. Each DI3270 workstation on a network supports up to four concurrent IBM mainframe host sessions. Each PC session emulates devices of the 3270 family of terminals. Printer sessions are 3287-emulating print spoolers. A single workstation may have concurrent active sessions at one or more gateways. A hot-key combination lets the user toggle in and out of DOS while host sessions continue to operate. LAN: level 1 (1 to 16 LUs), $1,295; level 2 (1 to 32 LUs), $2,495; level 3 (1 to 254 LUs SNA/SDLC only), $3,695. Single PC: 1 copy, $475; 2 to 8 copies, $425 each; 9 copies and up, $375 each.
Data Interface Systems Corporation, 827 Harris Avenue, P.O. Box 4189, Austin, TX 78765; 800/351-4244; in Texas, 512/346-5641

CIRCLE 330 ON READER SERVICE CARD

Ryan-McFarland Corporation has announced beta testing of XENIX V/386 versions of its **RM/FORTRAN** and **RM/COBOL-85** compilers, which take advantage of the powerful instruction set and large address space of the 80386. RM/FORTRAN includes mainframe extensions from VAX, VS, and FORTRAN-66, and supports virtually unlimited program and array size; it performs both local and global optimizations to produce efficient 80386 object code for high-speed execution. RM/COBOL applications can be moved virtually unchanged to the 80386 from more than 250 environments that it currently supports. These two compilers should become available in late 1987.
Ryan-McFarland Corporation, 609 Deep Valley Drive, Rolling Hills Estates, CA 90274; 213/541-4828

CIRCLE 334 ON READER SERVICE CARD

Revision 8 of **Business Basic Extended** (BB^x) from **BASIS, Inc.** has added support for the Intel 80386 under DOS and XENIX, the RT PC under AIX, and the PC Convertible and Toshiba portable in the 3½-inch diskette format. BB^x is a multiuser, multitasking Business BASIC that supports DOS, XENIX, UNIX, and Multi-Link, as well as networks from IBM, Microsoft, and Novell. BB^x features windows support, extended variable and function names, string arrays, STRING and DIRECTORY file types, operating system shell commands, and extended screen types (including color). For DOS, $295 to $595; XENIX, $695; UNIX, $695 to $5,000.
BASIS, Inc., 5700 Harper Drive NE, Suite 290, Albuquerque, NM 87109; 505/821-4407

CIRCLE 341 ON READER SERVICE CARD

The **PC-CICS** package from **Micro Focus** emulates CICS, the mainframe transaction processing monitor. As a companion to Micro Focus' VS COBOL Workbench, PC-CICS allows mainframe users to develop and test their CICS applications on a PC. It permits selected applications to migrate onto the PC for single-user operation. Finally, PC-CICS lets the user create new applications that run on both PC and mainframe. $1,500; PC runtime version, $100.
Micro Focus, 2465 E. Bayshore Road, Suite 400, Palo Alto, CA 94303; 415/856-4161

CIRCLE 335 ON READER SERVICE CARD

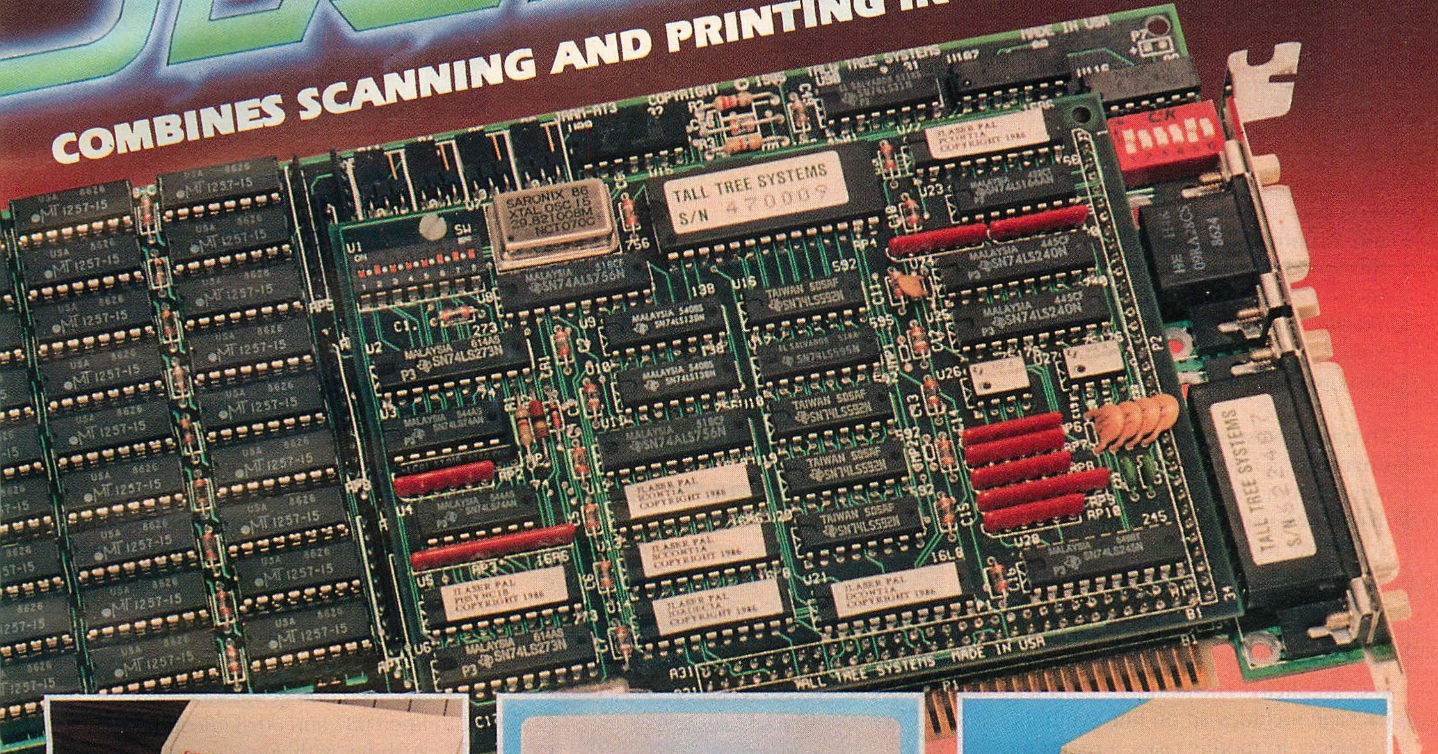
A multifunction, hard-disk management program, entitled **Pdisk**, has been released by **Phoenix Technologies, Ltd.** Comprised of 10 utilities, Pdisk features facilities for advanced backup and restore, head parking, memory cache, and DOS simplification. $195.
Phoenix Technologies, Ltd., 320 Norwood Park S, Norwood, MA 02062; 617/769-7020

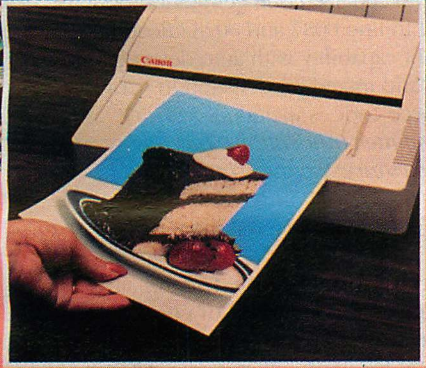
CIRCLE 336 ON READER SERVICE CARD

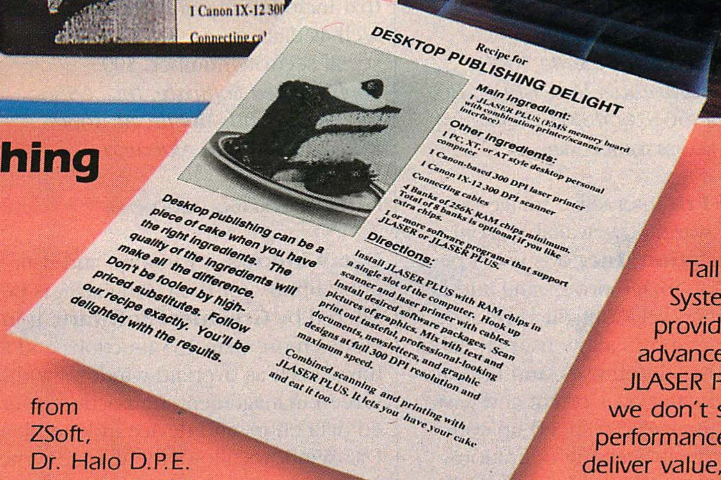
Rational Systems, Inc. has released **Instant-C 2.0**, an incremental compiler for the C language that processes only those parts of the program that the user changes, rather than all of the source code files. Instant-C combines the interactive environment of an interpreter with the speed of a compiler. The new release supports programs up to 640KB in size. Version 2.0 incorporates a full-screen editor, source-level debugger, object-code linker, source-code checker,

JLASER PLUS

COMBINES SCANNING AND PRINTING IN A SINGLE BOARD!







It makes desktop publishing a piece of cake!

Tall Tree Systems introduces another breakthrough in desktop publishing with JLASER PLUS. We've combined a 2 MB EMS memory board and an interface to *both* a Canon®-based laser printer and scanner. JLASER PLUS increases the performance of both devices and gives you a low-cost solution to the *limitations* you've been experiencing with them.

Furthermore, the same memory that is made available to your printer and scanner is also available for all your other conventional applications. You get system memory, expanded LIM memory, extended memory in an AT-type machine, RAM Disk and print spooler — all in a single slot!

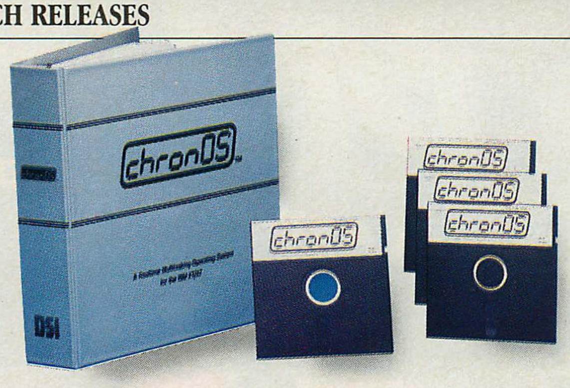
Supporting JLASER PLUS is a host of software packages, such as PC Paintbrush + from ZSoft, Dr. Halo D.P.E. from Media Cybernetics, LaserGL from Software Express, Ventura Publisher from Xerox, Page Builder from White Sciences, Le Print from Le Baugh Software, Fancy Font and Fancy Word from SoftCraft, Inc., and many more to be announced.

It takes a technological innovator like Tall Tree Systems to provide a major advancement like JLASER PLUS. And we don't stop at performance. We also deliver value, which is truly icing on the cake.

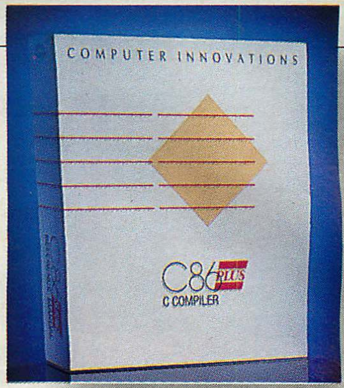
TALL TREE SYSTEMS
1120 San Antonio Road
Palo Alto, CA 94303
(415) 964-1980

CIRCLE NO. 194 ON READER SERVICE CARD

TALL TREE SYSTEMS



Realtime, multitasking chronOS by Dynapro Systems, Inc.



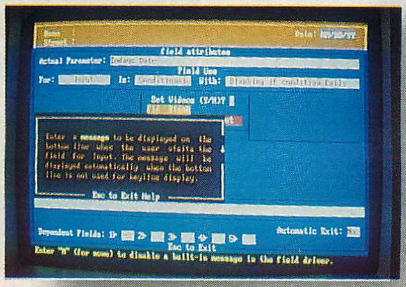
Computer Innovations' latest C compiler, C86PLUS

and a runtime checker, which includes checking invalid or null pointer references and array bounds. $495.
Rational Systems, Inc., P.O. Box 480, Natick, MA 01760; 617/653-6194
CIRCLE 338 ON READER SERVICE CARD

Dynapro Systems, Inc. has released **chronOS**, a realtime, multitasking operating system for the PC/XT and PC/AT that allows users to rely on DOS programming tools to write realtime applications. Written in assembly language and tailored for the iAPX86 family of microprocessors, chronOS uses the DOS environment for low memory overhead and simplicity. The standard chronOS package includes an on-line symbolic debugger to modify tasks; a reentrant window manager to view as many as 64 tasks, (each in a window of its own); device drivers; interfaces for assembly language, C, and FORTRAN; a priority-based, preemptive task scheduler; intertask communication; and runtime-definable timers. U.S. site license, $1,995; Canadian site license, $2,495.
Dynapro Systems, Inc., Suite 1000, 1200 W. 73rd Avenue, Vancouver, BC, Canada V6P 6G5; 604/263-2638
CIRCLE 333 ON READER SERVICE CARD

DT/Image-Pro interactive image-processing software, now available from **Data Translation, Inc.**, lets users perform realtime image processing and fast graphics functions. Controlled by a mouse, the graphics allow users to label images, add grids, ellipses, and lines to images, and paint over or cut and paste portions of images. To speed up complicated image-processing operations, DT/Image-Pro implements its algorithms using the specialized Data Translation frame-grabber and frame-processor boards. The user selects functions from a hierarchy of menus. $1,495.
Data Translation, Inc., 100 Locke Drive, Marlboro, MA 01752; 617/481-3700
CIRCLE 340 ON READER SERVICE CARD

A code generator for Turbo Pascal from **Sophisticated Software, Inc., turboMAGIC** can create screens that update automatically to show relationships among fields. With a full-featured editor to paint colorful forms up to 66 lines long for data entry, the user can create pop-up menus and complete pull-down menu systems. Other features include scrolling within framed windows and a user-expandable collection of field types that includes all standard Pascal types as well as date, menu, telephone, and social security number. $99.
Sophisticated Software, Inc., 6586 Old Shell Road, Mobile, AL 36608; 800/225-3165; in Alabama, 205/342-7026
CIRCLE 337 ON READER SERVICE CARD

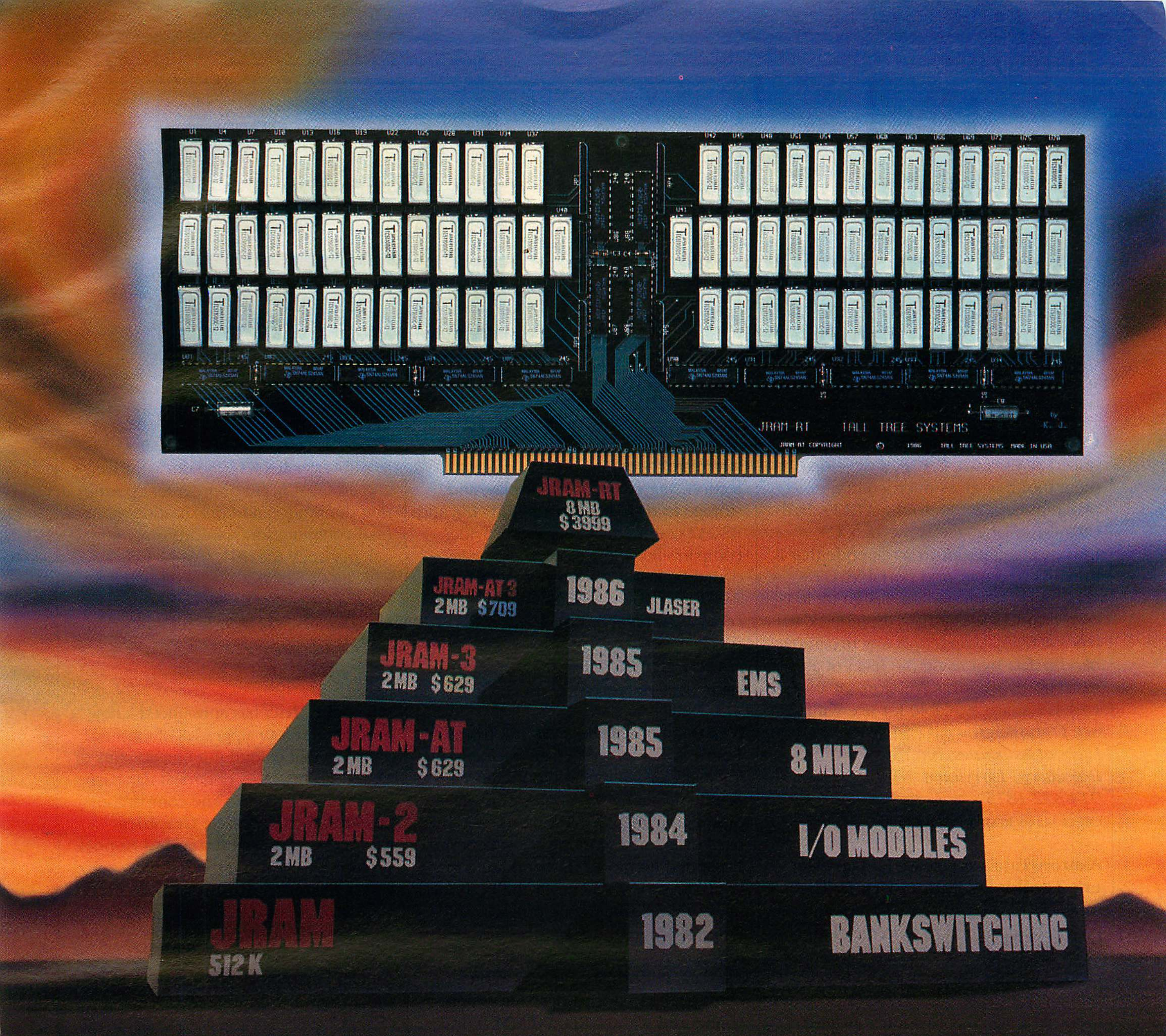


turboMAGIC menu screen, from Sophisticated Software

DataWindows, a windows and data-entry library for the C language, is being offered by **Greenleaf Software**. It includes more than 135 functions and features, such as overlaid windows with screen management, transaction oriented data entry, and device independence. DataWindows allows the user to write to any window (on-screen or not). Users may include portions of the object code in programs with no royalty obligations. $225; source code, $225.
Greenleaf Software Inc., 1411 LeMay Drive, Suite 101, Carrollton, TX 75007; 800/523-9830; in Texas, 214/446-8641
CIRCLE 339 ON READER SERVICE CARD

C86PLUS, a C compiler based on artificial intelligence techniques, produces highly optimized code and takes advantage of hardware architectures such as Intel's 80286 and 80386. From **Computer Innovations, Inc.**, C86PLUS includes the latest ANSI C library functions such as register variables; structure assignment; function prototypes; new type modifiers such as **const**, **volatile**, and **signed**; long-double, 80-bit, floating-point operations; and enumerator data types. C86PLUS features a library of more than 300 functions, including UNIX System V-compatible facilities, small-, medium-, and large-memory-model support; 8086 and 80186/286/386 code generation options; and in-line 8087 and 80287 floating-point capability with auto-detect emulator and mixed model support. Library source code is included. $497.
Computer Innovations, Inc., 980 Shrewsbury Avenue, Tinton Falls, NJ 07724; 201/542-5920
CIRCLE 332 ON READER SERVICE CARD

Barrington Systems, Inc. has announced the **removal of copy protection** from **Clarion**, a programming language for corporate programmers and independent developers. Version 1.1 offers 15 major enhancements in all, including a convert utility that allows the import/export of DIF, dBASE II, dBASE III, and BASIC files, and the availability of no-cost runtime modules to support Clarion-based applications. It features a cross-reference utility, an open file extension that bypasses the DOS limitation and now supports 255 open files using DOS 3.0 and 99 for DOS 2.1, a file-selection window that acts like a minidirector utility, and support for the enhanced PC/AT keyboard, including function keys. $395; upgrade, $100.
Barrington Systems, Inc. 150 E. Sample Road, Suite 200, Pompano Beach, FL 33064; 800/354-5444; in Florida, 305/785-4555
CIRCLE 344 ON READER SERVICE CARD



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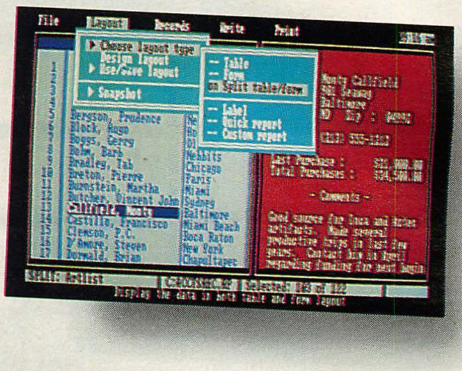
Lifeboat Associates' ADVANTAGE C++ development tool



RapidFile screen, from Ashton-Tate

Lifeboat Associates, Inc. has introduced **ADVANTAGE C++**, a development tool that gives microcomputer programmers access to the AT&T's Bell Labs C++ language. ADVANTAGE C++ thus makes it easier to write code that is reliable, reusable, and portable. C++ enables programmers to design their own data types. The user-designed data types actually change the way programs handle data by raising the level of abstraction procedures. Versions of ADVANTAGE C++ are available for use with Lattice C and Microsoft C. $495.
Lifeboat Associates, Inc., 55 S. Broadway, Tarrytown, NY 10591; 914/332-1875
CIRCLE 342 ON READER SERVICE CARD

Ashton-Tate has released a **Developer's Toolkit** for **Framework II**. The toolkit is a collection of routines and programs designed to help developers write faster, more efficient custom applications with Framework II's FRED development language. The software provides tools to create and customize printer drivers, create new import and export file utilities, maintain and use dBASE files from within Framework II, and develop computer-based training materials. $149.

A file manager called **RapidFile** enables users to manage data, create reports, write form letters, and produce mailing labels. The product uses dBASE III PLUS files, which provides transparent accesses to dBASE data. $495.
Ashton-Tate, 20101 Hamilton Avenue, Torrance, CA 90502; 213/329-8000
CIRCLE 343 ON READER SERVICE CARD

Lotus Development Corporation has introduced **Lotus Measure**, a package that collects data from measurement instruments and devices and puts them directly into Lotus 1-2-3. Measure works with 1-2-3 as a single program; it employs the identical user interface and macro environment, and because macros can incorporate both 1-2-3 and Measure functions, a single macro can automate the entire process of data collection, analysis, graphic display, and storage to disk. It supports IEEE-488 and RS-232 communications and provides compatibility with selected analog-to-digital boards as well as with more than 8,000 instruments and devices. $495.
Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, MA 02142; 617/577-8500
CIRCLE 345 ON READER SERVICE CARD

NVRD, a nonvolatile RAM disk from **Fort's Software**, improves performance for many disk-intensive applications. NVRD maintains two copies of its RAM disk; a nonvolatile "backing file" on the hard disk and a working copy, kept in expanded memory. The working copy is temporarily lost whenever the PC boots up, but the backup copy remains valid. When a program writes to a nonvolatile RAM disk, NVRD updates both copies of the data. Performance during writes is comparable to a hard disk. On systems configured with NVRD, **V-EMM** (Fort's virtual expanded memory manager) and an expanded memory board, the trio function as a disk-caching program, however, the amount of memory assigned to NVRD varies with the activity of other expanded memory applications. NVRD, $49.96; V-EMM, $119.90.
Fort's Software, P.O. Box 396, Manhattan, KS 66502; 913/537-2897
CIRCLE 346 ON READER SERVICE CARD

RTCS/Real-Time Computer Science Corporation is now shipping **RTX286**, a realtime, multitasking, multiuser operating system for the PC/AT. RTX286 is a complete implementation of Intel's iRMX286 operating system. It takes advantage of the protected mode of the iAPX286 processor by offering memory access protection, as well as allowing users to directly access as much as 16MB. **RTX286-C** is a version that can be configured for users who must add special device drivers. RTX286-C consists of object libraries for RTX286 device drivers and an OEM license agreement permitting duplication and distribution of the final configuration software on a nominal, per-copy fee. RTX286, $2,395; RTX286-C, $2,795.
RTCS/Real-Time Computer Science Corporation, 1390 Flynn Road, Camarillo, CA 93010; 805/987-9781
CIRCLE 347 ON READER SERVICE CARD

Microrim, Inc. has announced a new product and four upgrades of existing products that extend the functionality of **R:BASE System V**, a relational database management system. The companion products include **R:BASE Graphics**, **R:BASE CLOUT**, **R:BASE Extended Report Writer**, **R:BASE Program Interface**, and **R:BASE System V Runtime**. More than 40 math, scientific, financial, and engineering functions give users the ability to compare relationships among their data and manipulate data in a spreadsheet fashion with R:BASE Graphics ($295). R:BASE CLOUT is an artificial intelligence, natural-query program ($295). R:BASE Extended Report Writer is now certified to operate on the IBM Token-Ring Network ($295). The R:BASE Program Interface has a library of routines for application developers that allows Pascal, C, and FORTRAN programs to access R:BASE files ($595). R:BASE System V Runtime provides a cost-effective, secure means of distributing applications, while providing all the capabilities found in R:BASE System V except the ability to create or modify database file structure or to create new applications ($250).
Microrim, 3925 159th Avenue NE, P.O. Box 97022, Redmond, WA 98073-9722; 206/885-2000
CIRCLE 362 ON READER SERVICE CARD

The material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the PC Tech Journal *editorial staff.*

Over 5 Years.
More Than 2,000,000 Times.
AST Has Increased
The Power Of The PC.
Now, Out Of This Experience
Emerges A Powerful And
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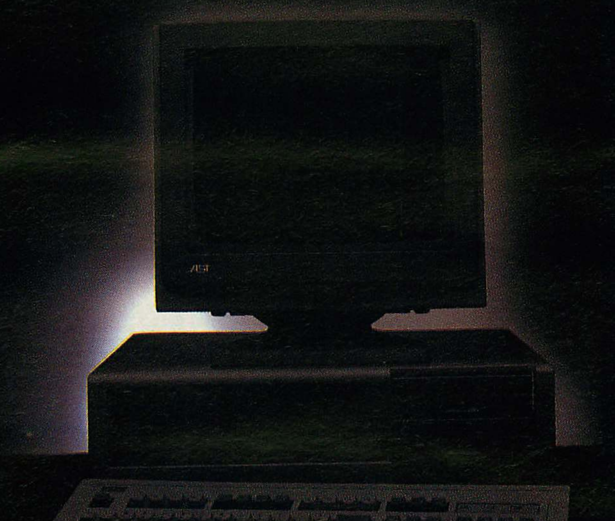
Built On Proven Technology.
Enhanced Like No Other.



Announcing
AST Premium/286.™

Discover AST Premium/286. The First AST Quality, Uncompromising AT® C

More than two million people have made us the first choice in PC Enhancement. For over five years, you've known AST as the leading PC enhancement company. Now, we're introducing the ultimate enhancement: AST Premium/286. The first AT-compatible personal computer with AST performance and reliability. More flexible and upgradeable. Skillfully combining lightning fast processing speed and uncompromising compatibility.

AST FASTslots:™ Processing speedways. Forming the foundation of the AST Premium/286's increased speed are our FASTslots. This advanced architecture improves overall performance so there's enough built-in power to satisfy even the most demanding user.

The AST Premium/286 operates 50% faster than an 8MHz PC AT® as measured by the Norton Utilities™ Version 3.0 SysInfo. And maintains full compatibility with standard PC and AT-based enhancement cards. It also provides for a powerful, easily upgradeable and expandable future, accommodating the next generation of accelerator and high-performance enhancement cards.

A Heritage Of Software Compatibility. Software compatibility has always been one of our strong points. Shipped with the industry-standard MS-DOS® 3.1, AST Premium/286 is compatible with widely accepted operating systems such as IBM® PC-DOS,™ Concurrent DOS™ and XENIX.™ It's also designed to get the most out of multitasking software packages like Microsoft® Windows, DESQview™ and TopView.™

Applications-oriented. Keyboard-selectable operation at 10, 8 or 6MHz means virtually all popular off-the-shelf IBM PC and PC AT application software is immediately compatible. All your favorites, including Microsoft Word, Lotus® 1-2-3,® Framework,™ Symphony,® dBASE® III and AutoCAD.™

Attain your fullest software potential. AST's advanced architecture also provides faster and more flexible memory addressing. While built-in Enhanced expanded memory capabilities—AST FASTRAM,™ expandable to 2MB in a single slot—let you break the 640K DOS barrier. Create bigger spreadsheets and sort larger databases. And enjoy the uninterrupted workflow benefits of multitasking using current DOS versions, with full support for protected mode software built-in.

Fast access disk storage. Complementing AST Premium/286's speedy operation is a full line of disk systems. There's a 20MB, 40MB and a 70MB hard disk. Both the 40MB and the 70MB offer more storage and faster access times—below 30msec—than the PC AT's fixed disk. And our external disk/tape systems, featuring advanced SCSI architecture, allow easy expandability.

Prices Start At $1995.00*

...Personal Computer With Legendary ...ompatibility and Lightning Speed.

More standards are standard. We build-in our AST FASTRAM™ memory card. And most models include our own multimode enhanced graphics adapter, supporting IBM EGA, CGA and Monochrome, and Hercules Graphics Card™ display modes.

Compatible with AST and IBM Products. AST Premium/286 is designed to remain your productivity partner for years to come. Choose it with confidence for single and multitasking applications, individual and shared environments alike. Use it as an engine with other AST products to form powerful application workstations for desktop publishing, CAD/CAE and more. Or to increase connectivity use it as a network file server, to communicate with IBM mainframes and minicomputers, or to manage multiuser environments.

Solutions that are ready to go. We also offer a number of pre-configured workstation solutions tailored for maximum performance in your application. Combining our proven products, from local area networking and data communications to extra memory and I/O to laser printers and disk systems, our solutions are all designed to increase your business productivity.

Quality across the board, around the world. When you buy AST products, you're also purchasing a worldwide reputation for service, support and product dependability. AST Premium/286 is backed by a one year limited warranty, and our worldwide network of certified dealers and service centers.

AST Premium/286—The system and the solutions. For more information call our Product Information Center at **(714) 863-0181** or send the coupon to: AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714-4992.

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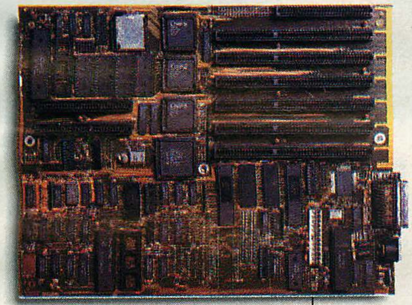
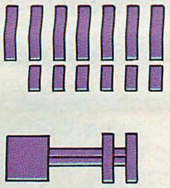
AST RESEARCH INC.

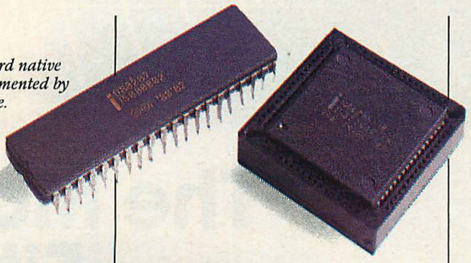


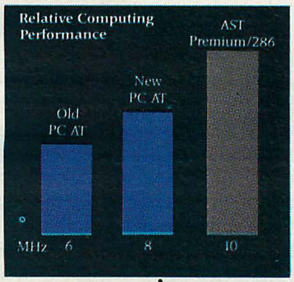
Seven industry-standard expansion slots; 1 PC-compatible slot, 6 PC AT-compatible slots, including two AST FASTslots. FASTslots provide no wait state operation with a high-speed direct interface to the 10MHz 80286 processor. Advanced architecture accommodates the next generation of accelerator and high-performance enhancement cards. It's also an open architecture for easy development and system integration.



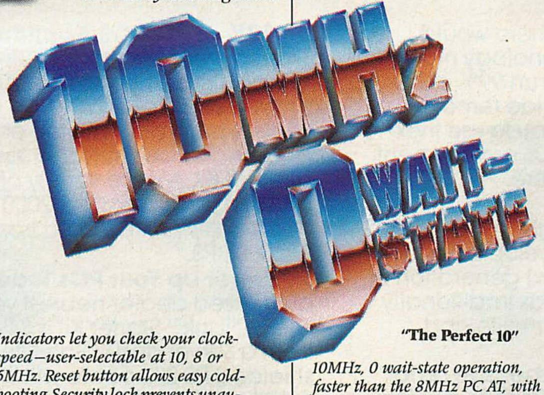
Based on industry-standard native 80286 technology, complemented by AST advanced architecture.

Coprocessor socket accepts 8MHz 80287 devices to execute math- and floating point-intensive programs faster.





Compare the increased speed of the AST Premium/286 against the top competitors for yourself. (Basis: Norton Utilities SysInfo Version 3.0)

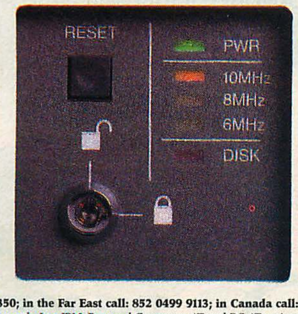


Two AT-compatible expansion slots with a plus: a third bus connector featuring lightning-quick CPU access time, for use with specially-designed cards like the AST FASTRAM Enhanced memory card. Expandable to 2MB in single slot, FASTRAM supports a variety of addressing capabilities—Enhanced EMS, EMS, extended (protected mode) and conventional memory addressing.

Enhanced, low-profile 101/102-key keyboard with separate numeric keypad, dedicated cursor control and extra function keys. International versions available.

AST Premium/286 is shipped with MS-DOS and GW BASIC,® and it's fully compatible with a wide variety of operating systems, operating environment and utility packages, and application software.

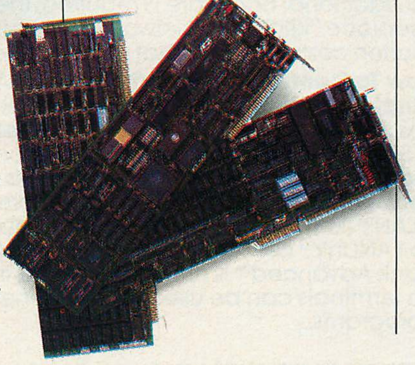
Indicators let you check your clock-speed—user-selectable at 10, 8 or 6MHz. Reset button allows easy cold-booting. Security lock prevents unauthorized keyboard access.



"The Perfect 10"

10MHz, 0 wait-state operation, faster than the 8MHz PC AT, with IBM PC AT hardware and software compatibility.

Supports standard PC, PC AT and AST FASTslot cards. With AST, you start with a lot, like our included FASTRAM Enhanced memory card and multimode Enhanced Graphics Adapter, but you've also got a lot of options. We offer the widest range of compatible enhancement products and peripherals to suit your needs—a true one-stop solution allowing you to expand and upgrade your system with the assurance of future service and support.



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apl language

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APL*PLUS/PC Tools Vol 1 *by STSC*	295	199
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APL*PLUS/UNX *For AT XENIX by STSC*	995	695
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Logic-Line Series 3 *by Thunderstone*	150	139
LPA microPROLOG *by Prog Logic Systems*	99	89
with APES	149	129
LPA Professional microPROLOG	395	339
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PC Scheme *by Texas Instruments*	95	85
Personal Consultant Easy *by TI*	495	439
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PROLOG-2 Interpreter *by ESI*	450	419
PROLOG-2 Interpreter and Compiler	895	839
QNIAL *by NIAL Systems*	375	349
TransLISP *from Solution Systems*	95	CALL
Turbo PROLOG Compiler *by Borland Intl.*	100	75

assembly language

386 ASM/LINK *Cross Asm by Phar Lap*	495	CALL
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ASMLIB *Function Library by BC Assoc*	149	129
asmTREE *B-Tree Dev System by BC Assoc*	395	339
Cross Assemblers *Various 2500 AD*	CALL	CALL
Microsoft Macro Assembler	150	98
Norton Utilities *by Peter Norton*	100	59
Turbo EDITASM *by Speedware*	99	84
UniWare Cross Assemblers *Various. New*	295	CALL
Visible Computer: 8088 *Software Masters*	80	65

basic language

BetterBASIC *by Summit Software*	200	129
8087 Math Support	99	75
Btrieve Interface	99	75
C Interface	99	75
Run-time Module	250	169
EXIM Services Toolkit *by EXIM. New*	CALL	CALL
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MACH 2 *by Micro Help*	75	65
Microsoft QuickBASIC	99	65
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BASICA Converter	50	45
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c++

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c compilers

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Datalight Developer Kit *w Large Model*	99	79
DeSmet C *w Debugger*	159	145
DeSmet C *w Debugger & Large Case*	209	193
Eco-C *Development System by Ecosoft*	125	89
Lattice C Compiler *from Lattice*	500	275
Mark Williams Let's C	75	58
with csd *Source Debugger*	150	109
Mark Williams MWC-86	495	289
Microsoft C *with CodeView*	450	275
UniWare 68000/10/20		
Cross Compiler *New*	595	CALL
Wizard C Combo *by Wizard Systems*	750	599
Wizard C Compiler	450	359
ROM Development Pkg	350	299

c interpreters

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C Trainer *with Book by Catalytix*	122	CALL
Instant C *by Rational Systems*	500	CALL
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programmer's connection

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TECH NOTEBOOK 72

MURRAY L. LESSER

The Root of the Problem

A modern equivalent of a time-honored technique cuts the time needed to calculate square roots in interpreted BASIC.

Building an intricate graphics program requires evaluation of thousands of square roots, but only to integer accuracy. BASIC compilers do it the hard way: they convert the integer function argument to a single-precision, floating-point number, take the square root of that, then convert the floating-point result back into an integer.

The assembly language subroutine in ROOT.ASM (listing 1) produces the nearest integer to the actual square root of an integer argument. It returns a zero value for a negative argument rather than an error. Because the routine has no absolute jumps, it could be used to speed up interpreted BASIC if it were coded into an integer array. ROOT also can be BLOADed into an interpreted basic program.

ROOT uses a modern equivalent of the old "subtract successive odd numbers" technique that was popular during World War II. (John Meggit generalized this technique in his 1962 paper, cited in listing 1; it since has replaced iterative procedures for calculating square roots, logarithms, and inverse trigonometric functions in pocket calculators and well-designed compiler libraries.)

An example of ROOT in use under Microsoft's QuickBASIC is given in ROOTTEST.ASM (listing 2). ROOTTEST runs four times faster using ROOT than it does using QuickBASIC's floating-point, square-root function.

Murray Lesser is an author and retired after 26 years at IBM.

LISTING 1: ROOT.ASM

```
;*************************************************************************
;                            ROOT.ASM                                    *
;  ROOT() is an assembled fast integer square root subroutine to be     *
; linked to Microsoft compiled BASIC programs.                           *
;   Call with ROOT(x,y) where x is an integer expression                 *
;                             y is an integer variable                   *
;  The square root of x will be returned in y.  (Negative input will    *
; return a zero.)                                                        *
;                                                                        *
;  ROOT is a binary adaptation of the synthetic division square root    *
; procedure shown in the paper by J. E. Meggit, "Pseudo Division and     *
; Pseudo Multiplication Processes." The IBM Journal of Research and      *
; Development, vol. 6, no. 2 (April 1962). pp. 210-226.                  *
;                                                                        *
;               Written by M. L. Lesser, April 13, 1986                  *
;               Assembled with Microsoft MASM version 4.00               *
;*************************************************************************

DATA    SEGMENT WORD PUBLIC 'DATA'      ;Dummy data segment for
DATA    ENDS                            ;  addressability
DGROUP  GROUP DATA

SQRT    SEGMENT BYTE PUBLIC 'CODE'
        ASSUME CS:SQRT,DS:DGROUP
        PUBLIC  ROOT

ROOT    PROC FAR
        PUSH    BP
        MOV     BP,SP
        MOV     BX,8[BP]
        MOV     AX,[BX]                 ;Argument of root routine (A)
        XOR     DX,DX                   ;Root will be accumulated in DX
        MOV     CX,8                    ;Makes eight passes through loop
        MOV     BX,4000H                ;Initial trial divisor (B)
        MOV     DI,8000H                ;Initial value of modifier (M)
        MOV     SI,2000H                ;Initial value of M/4
        CMP     AX,DX                   ;Check for negative input
        JLE     DONE                    ;Return zero if negative input
DOIT:   SHL     DX,1                    ;Get next bit of root
        CMP     AX,BX                   ;Test for next root bit
        JL      NEXT                    ;If A < B then skip root bit
        INC     DX                      ;Insert next bit of root
        SUB     AX,BX                   ;Subtract trial divisor
        ADD     BX,DI                   ;Increment B by M
NEXT:   SUB     BX,SI                   ;Decrement B by M/4
        SHR     DI,1                    ;Divide M by 4 for next cycle
        SHR     DI,1
        SHR     SI,1                    ;Divide M/4 by 4 for next cycle
        SHR     SI,1
        SHR     BX,1                    ;Divide trial divisor by two
        LOOP    DOIT
        CMP     AX,BX                   ;Test for roundup bit
        JLE     DONE
        INC     DX
DONE:   MOV     BX,6[BP]
        MOV     [BX],DX                 ;Store root
        POP     BP
        RET     4

ROOT    ENDP
SQRT    ENDS
        END
```

LISTING 2: ROOTTEST.ASM

```
' TEST.BAS  an example of the use of ROOT.ASM
'  compile with a Microsoft BASIC compiler and link to ROOT.OBJ

        defint a-c
        defsng d
        for a = 0 to 32766
          call root(a,b)
          let d = sqr(a)
          let c = d
          gosub 1000
          if inkey$ = chr$(3) then end          'Emergency exit
        next a
        let a = 32767
        call root(a,b)
        let d = sqr(a)
        let c = d
        gosub 1000
end
1000    print a,b,c,d
        if b <> c then while inkey$ <> "":wend  'Error pause
        return
```

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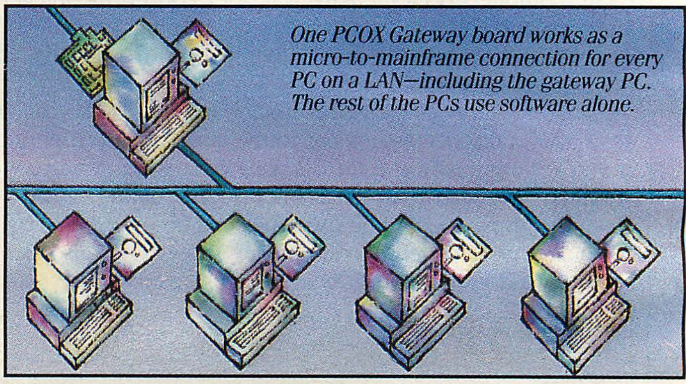

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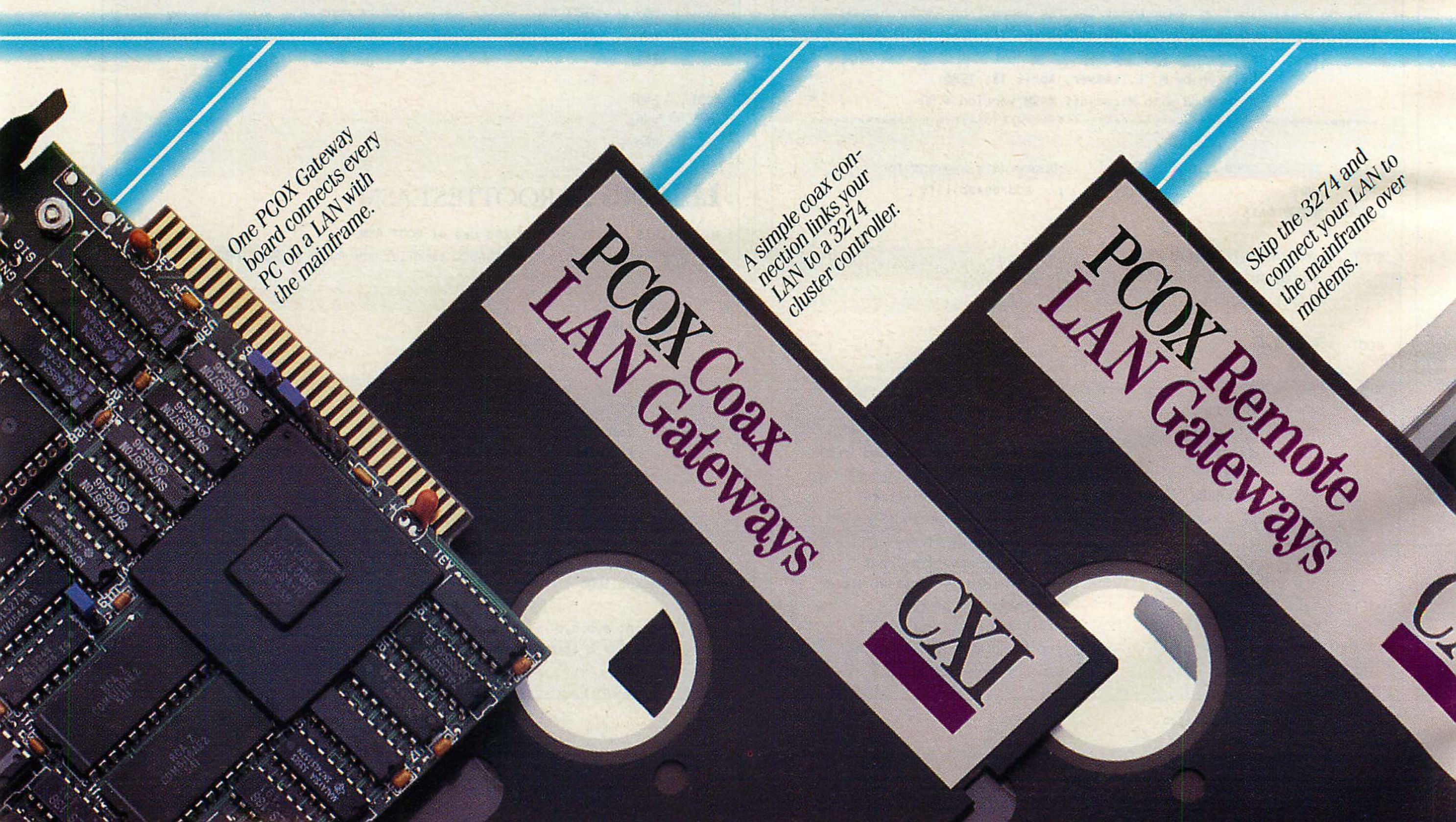

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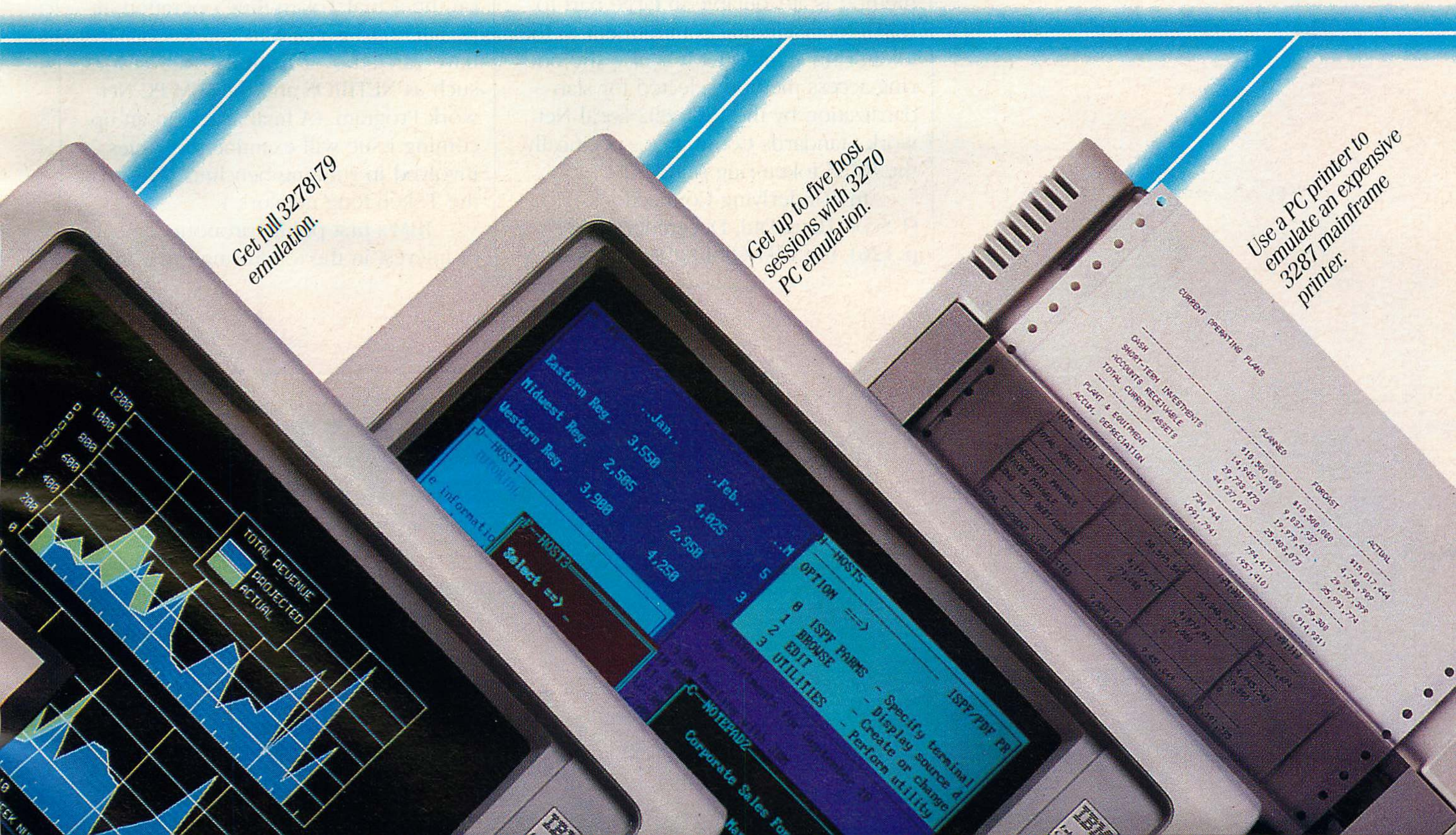
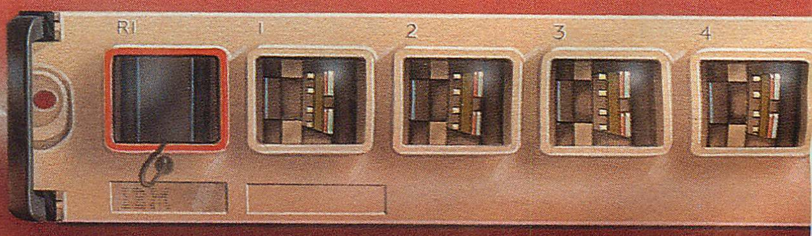


The Token-Ring Solution

Token-passing is the prevalent means of ring control for local area networks (LANs) in the United States. The popularity of this method is attributable in large part to IBM's long-standing commitment to the token-ring technique. It is also the one ring-access method selected for standardization by the IEEE 802 Local Network Standards Committee, specifically, the 802.5 token-ring standard.

In "Underlying Connections" (J. Scott Haugdahl, December 1986, p. 126), the IBM Cabling System was examined in its role as support for the IBM PC Token-Ring LAN. This article examines the operation of the Token-Ring and related products. The emphasis is on the actual Token-Ring operation; little attention is given to applications that have carried over from the PC Network, such as NETBIOS and the IBM PC Network Program. (A final article in an upcoming issue will examine the issues involved in running benchmark tests on the Token-Ring network.)

IBM's first public pronouncement of interest in the token-ring came in a



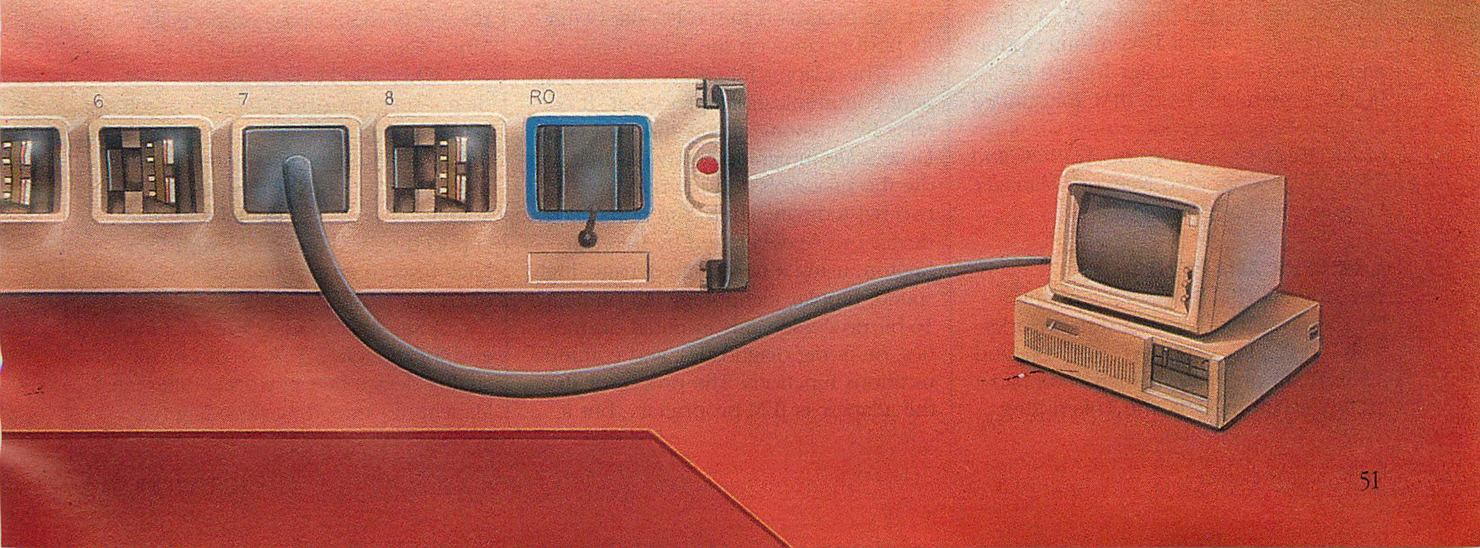
J. SCOTT HAUGDAHL

The IBM Token-Ring LAN is the long-awaited key to linking PCs in an efficient, powerful arrangement that is finally more productive than troublesome. It boasts a range of present and future connectivity options.

series of four papers it presented to IEEE 802 in March 1982 and at an International Federation of Information Processing (IFIP) conference in Florence, Italy, in April 1982. The March disclosures described a new architecture; the IFIP presentation dealt with implementations of that architecture. In August 1982, at an IBM users' group meeting, the company presented a fifth paper on wiring. IBM then presented the IEEE 802 papers at the IEEE Computer Society's semiannual conference, COMPCON, in the fall of that year.

The next major development was a public demonstration at Telecom 1983 (in Geneva, Switzerland) of a Token-Ring prototype. In this simplified version, an attached device gained access to the network by changing the status of a perpetually circulating 1-bit token from free to busy. The token is in the header of a message frame, which then is filled with all or part of the message itself. The demonstration ring simply consisted of a wiring concentrator connected to several terminals, including 3270 terminals, 8775 display terminals,

ILLUSTRATION • ANDY LEVINE



a 3275 front-end processor, and 8100 distributed processors.

In May 1984, IBM announced the IBM Cabling System, a system designed to connect all IBM data communications devices and to accommodate the still-to-come Token-Ring. In October 1985, the official announcement of the IBM PC Token-Ring Network was made, along with a series of other products for the IBM PC family. IBM felt that its 4-Mbps (megabits per second) rate was adequate for departmental/office automation requirements, that the token-passing protocol offered superior throughput under heavy loads (compared with 3Com's EtherNet), and that the protocol was better suited to supporting IBM's synchronous devices.

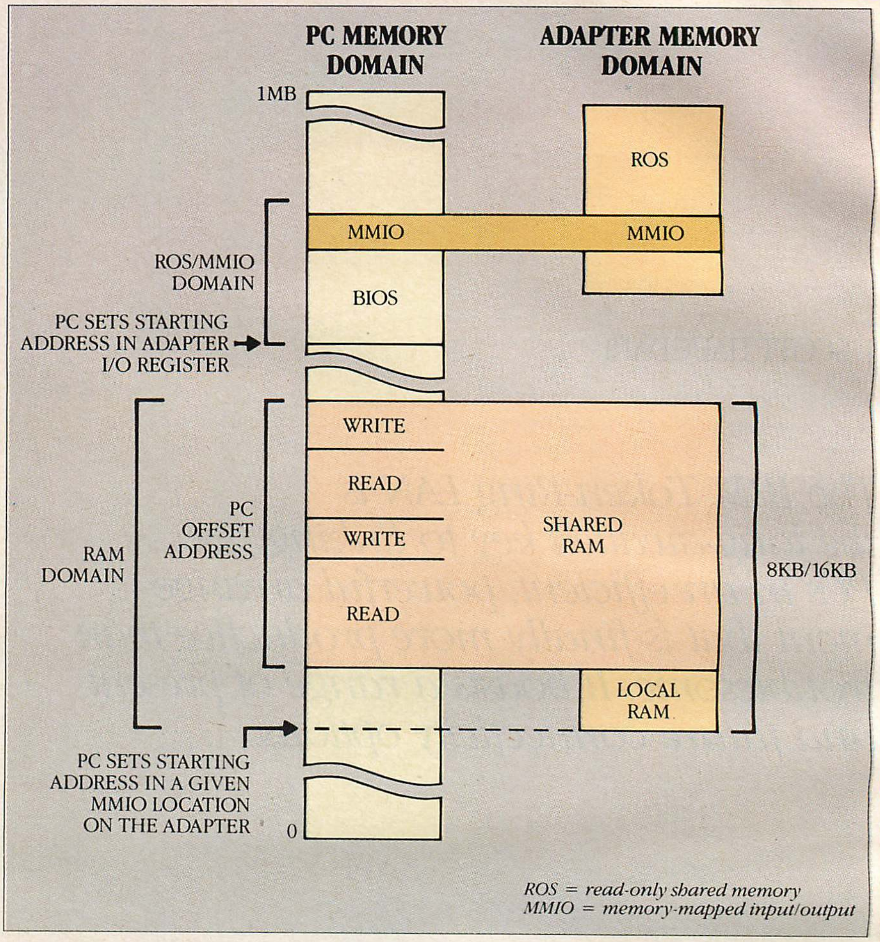
Concurrent announcements to the Token-Ring included the Multistation Access Unit (MAU), support for telephone wire (type 3), the Asynchronous Communications Server, the IBM PC Token-Ring Adapter, the NETBIOS Emulation Program, enhancements to the 3270 SNA Emulation Program, and APPC/PC (Advanced Program-to-Program Communication for the PC). The IBM PC Local Area Network Program was released with DOS 3.2.

The October announcement generated a lot of criticism in the areas of system sizing and interconnectivity. Only a single ring was supported with a maximum of 260 devices over a limited distance. The only direct connection was an adapter for the PC.

An announcement made in April 1986, however, quieted the critics. True to IBM's claim that the Token-Ring is evolutionary (not revolutionary) in nature, several missing pieces were announced. These included copper and fiber repeaters; the PC Adapter II; a lower-cost, data-grade, type-9 wire; a bridging program for multiple rings; a Network Manager program; and new host attachments for System/36 (via a PC/AT) and System/370 (via a 3725).

Minor announcements in May and June of 1986 added the new 3174 Cluster Controller with a Token-Ring option and a Token-Ring Adapter for the RT PC. In September 1986, IBM announced a Token-Ring starter kit, a new version of NETBIOS to support the 3270-PC and 3270-AT, an upgraded Network Manager Program, and NetView/PC.

FIGURE 1: *Shared Memory Map*



The shared memory can be accessed as 8-bit-wide memory from the host or as 16-bit-wide memory from the adapter's microprocessor. The host processor can set certain areas of the shared memory to read-only to protect them from corruption.

A BETTER ADAPTER

The original IBM Token-Ring Adapter for the PC is a full-size card that works with the PC, PC/XT, PC/AT, 3270-PC, and 3270-AT. In order to maintain compatibility with all models, the Token-Ring Adapter does not use the extended 16-bit bus available in the AT. Fortunately, this choice does not affect performance. By using a shared memory interface rather than a DMA (direct memory access) channel, the adapter overcomes the 8-bit DMA deficiency of the AT (in 8-bit mode, it actually operates slower than an XT), and scarce DMA channels are preserved. In their place, a block of reserved memory is used. And, the faster the processor in the PC, the better its performance on the Token-Ring.

The adapter functions as an intelligent communications processor. It contains five custom analog and VLSI (very large scale integration) devices that handle the protocols and interface to the two twisted-pair wires. The nonanalog devices were developed by IBM/Burlington, using a new, high-density, high-speed, bipolar technology. An on-board 16-bit processor aids in initial diagnostics, on-going diagnostics, and communications functions. The processor in the adapter is IBM-proprietary, but it carries a Motorola symbol, indicating that the adapter is not based on an Intel microprocessor technology.

The microprocessor executes resident microcode (32K-by-16-bit words arranged as two 32K-by-8-bit EPROMS) that provides the host access to logical-link functions according to IEEE 802.2 LLC (logical link control) or physical-link functions according to IEEE 802.5 MAC (media access control). The initial release of the adapter supports the 4-Mbps data rate, as specified by 802.5.

When the PC is booted, built-in diagnostics perform a power-on-self-test (POST) procedure. The POST checks all the internal operations of the adapter, including the on-board timers. The adapter also checks the lobe cabling (up to the MAU and back) with *loop-back* tests to ensure that the cable is indeed operating properly.

A single chip functions as a front end for the adapter. It is, essentially, an analog device that performs differential Manchester encoding/decoding (ex-

plained below), data synchronization, and physical insertion/removal from the ring. The chip is transformer-coupled in order to isolate the adapter from the cable electrically.

The two-chip protocol handler (one for transmit, one for receive) performs parallel-to-serial conversion, encoding/decoding of data (from the front end), CRC (cyclic redundancy check) generation and checking (removal), DMA to shared memory, monitor function, and detection of ring errors. The protocol handlers operate at speeds as high as 40 Mbps, thus accommodating *ring bit* rates higher than 4 Mbps.

The shared memory is organized as four banks and eight banks, respectively, of 4K-by-4-bit static RAM on the original Adapter and the Adapter II. It can be accessed as 8-bit-wide memory from the host or as 16-bit-wide memory from the adapter's microprocessor. The shared memory starting address can be programmed by the host, thereby eliminating the need to set switches. Any 8KB/16KB boundary can be programmed and certain areas of the shared memory can be protected from corruption (set to read-only) by the host. Figure 1 shows a rendering of how shared memory might be mapped into the PC memory domain and how certain areas might be protected.

This memory-mapped scheme has caused problems for third-party PC vendors as well as for users. Several IBM technical reference manuals warn that certain areas of memory are "reserved for future use." Some vendors have used these reserved areas in spite of the warning, resulting in their add-on boards not functioning properly with the Token-Ring Adapter installed. However, most vendors (Intel, for example, with its Above Board) have begun to provide corrections to this problem.

Other questions have come up regarding the I/O address space. Originally, IBM used a 10-bit I/O address allocation, but the Token-Ring Adapter decodes 12 bits. This may cause conflicts for boards that are not designed to ignore addresses over 10 bits long. The Digital Communications Associates' IRMA card was one of them, but it has been modified to avert the problem.

Although not immediately apparent, the Token-Ring Adapters have been engineered to accommodate future IBM PCs. In addition to the high-speed protocol processors and a 16-bit microprocessor, IBM chose high-speed static RAMs operating in the sub-65-nanosecond access-time range. This more than satisfies the AT or future PC memory requirements (such as the PC/XT-286 with its zero-wait states).

In addition to the shared memory interface (also referred to as MMIO, or memory-mapped input/output), certain functions are controlled by the programmable I/O (PIO) interface via a location in the PC's I/O space. The address of this I/O location is set via a DIP switch on the adapter. This I/O port provides access to one of eight 2-byte control registers. These registers control functions that include bidirectional interrupt and status, the PC-shared RAM starting address, the PC-shared RAM management (which takes care of setting protected areas), timer control at the millisecond (ms) level, and the PC timer value register.

The adapter provides interval timers that ensure proper token operation of the ring, and a general-purpose, 10-ms timer accessible by the host PC. It also includes the dead-man timer, a 120-ms timer that checks to see if the adapter code is executing; if this timer expires, a procedure is begun to remove the bad adapter from the ring.

By using a shared memory interface rather than a DMA channel, the adapter is able to overcome the 8-bit DMA deficiency of the AT.

The interface between the adapter and the host is handled by a custom gate array: the attachment interface. This proprietary array was designed by IBM and manufactured by OKI Semiconductor; no complete disclosure of its exact function has been made. Clearly, it handles the contention for shared memory, and most likely it controls the I/O port assignment and the read/write functions to the port registers that probably are located on the chip.

Provision has been made for an 8K-by-8-bit ROM BIOS option (the ROS, or read-only shared memory, in figure 1), although IBM had not released such an option at the time this article was written. When it becomes available, the option likely will allow a PC to be booted remotely from the network without using a local drive.

For attachment to the network, the adapter card provides a standard DB-9-type connection to the PC adapter cable. Pins 1, 6, 5, and 9 are used to connect to receive +, receive −, transmit −, and transmit +, respectively. The adapter cable, a flexible eight-foot, type-6 strand, connects to data-grade (type 1, 2, or 9) media. An optional type-3 media filter is available for use when type-3 wire is employed.

The adapter comes with a diskette containing the adapter handler (the Token-Ring Extended User Interface, or TOKREUI), the adapter diagnostics program, and a ring diagnostics program for use during operation of the ring.

IBM has released an upgraded technical reference to support the built-in enhancements to the Token-Ring PC Adapter II. According to IBM's official release, the Adapter II appeared simply to add more RAM (8KB), so that it could process more frames of larger size, handle more names and sessions within NETBIOS, and so on. These capabilities were necessary for the bridge program and System/36 interconnect. But a more important improvement was made as well. New commands (those executed by the on-board 16-bit microprocessor) were added to support the System/36 and bridging environments. An important new command allows a host to add more links to a service access point (SAP), as defined by IEEE 802.2, without the previously required connect/disconnect command sequence. This new command improves the performance of a host acting as a server.

IBM VERSUS TI CHIP SET

Although both the IBM and Texas Instruments (TI) chip sets provide a functional IEEE 802.5 interface, several subtle differences are noteworthy between the two implementations.

IBM generally does not offer its chip set to other vendors. In this case, TI and IBM collaborated during the development of the TI chip set, with IBM supplying the functional specification. Currently, TI is the only "third-party" vendor to offer an IEEE 802.2/802.5 chip set (Ungermann-Bass developed a set on its own). The joint IBM/TI agreement was announced in September 1982; the TI chip set was announced on October 15, 1985, the same day as IBM's formal Token-Ring announcement. A system developed with TI's chip set will be fully IEEE 802.5-compatible with IBM-developed Token-Ring adapters. (More than 200 vendors have requested TI chip set evaluation kits.)

Both the TI and IBM sets are essentially five-chip implementations. The TI set as a whole is called the TMS380 LAN Adapter chip set. Roughly speaking, the

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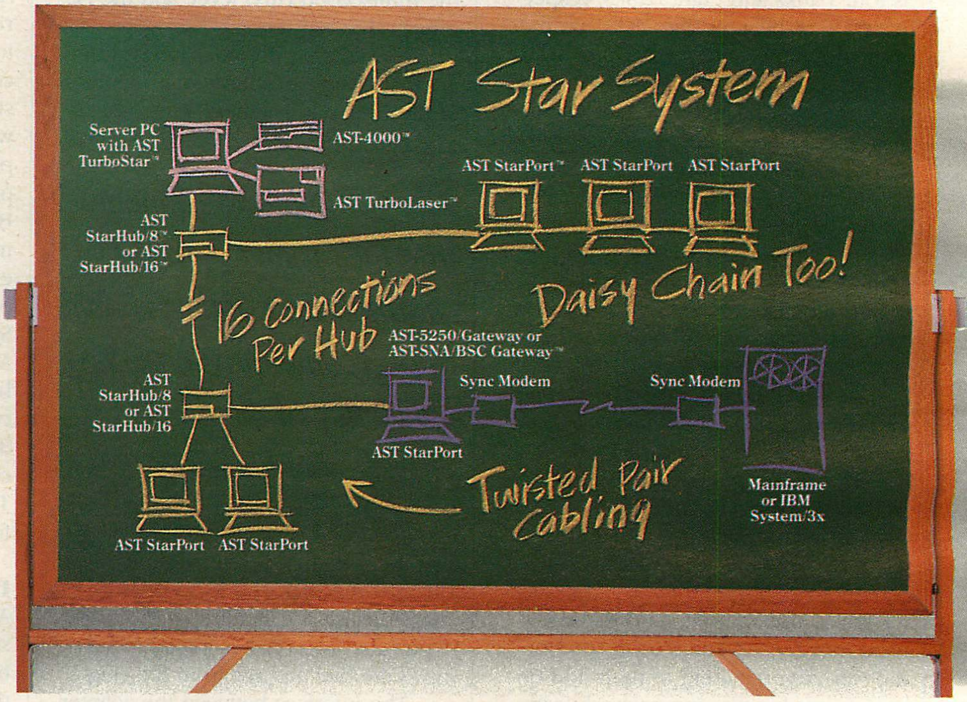

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TMS38030 System Interface is analogous to the IBM Attachment Interface, the TMS38010 communications processor to the IBM 16-bit processor, the TMS38020 protocol handler to the twin IBM protocol handler chips, and, finally, the TMS38051 ring interface transceiver and the TMS38052 ring interface controller to the IBM front end.

The IBM chip set uses an 8-bit shared memory interface, while TI depends on a DMA channel. The TMS380 reference book provides a sample schematic for an AT adapter card. Using the 16-bit DMA feature of the AT, the performance of the adapter card is comparable to that of the IBM set.

The TI communications processor (CP) is a dedicated, 16-bit CPU with 2.75KB of on-board RAM. The CP executes the firmware contained within the 16KB ROM on the TMS38020. Furthermore, the CP can access an additional 42KB of external RAM or ROM.

The TI protocol handler (PH) executes the functions of IEEE 802.5, LAN management services, ring operation, and diagnostics of the chip set. In accordance with the 802.5 specification, the PH implements differential Manchester encoding/decoding and frame-address recognition (group, local, and function). The PH contains four DMA channels, two for transmit and two for receive. In addition, all data paths and registers contained in the chip are parity-checked for increased reliability and integrity of operation.

TI's system interface (SI) provides a maximum 40-Mbps data transfer using its built-in DMA controller. The host system bus interface can be programmed to handle two major families of processors: the Intel 8086 and the Motorola 68000. The DMA feature can handle linked lists within the host memory. Commands (for example, TRANSMIT, RECEIVE, and READ ERROR LOG) are sent from the host to the SI via command blocks within a high-level command structure.

The ring interface is handled by the TMS38051 interface and TMS38052 interface controller. The ring interface contains a phase lock loop for clock recovery, data detection, and phase alignment. It provides the clock for the ring, when in active monitor mode, as well as the phantom drive signal for the MAU, a loop-back path for diagnostics, and error detection of wire faults.

A major difference between the two chip sets is the lack of an 802.2 interface in the TI set (which is one reason for the lag in third-party support of this set). But the 802.2 is a standard that is still evolving. The MAC specification seems to be the only *established* aspect of the Token-Ring. This lack of a completely established 802.2 standard is causing compatibility grief among third-party vendors. IBM's move to separate 802.2 from 802.5 in the same chip set appears to reflect its concern.

Surprisingly, IBM is using TI's chip set in the adapter card for the RT PC. It seems strange that IBM did not mention this fact in its original press announcement in order to help underscore compatibility between the two chip sets. The problem for developers is that the interfaces to use this RT Token-Ring adapter are as yet unavailable. Why did IBM go outside for this adapter? Possibly because it wanted an RT Token-Ring adapter quickly and did not have the resources at the time to develop it.

Users who want to achieve IEEE 802.2 compatibility with the IBM Token-Ring should follow IBM's lead (or even TI's, because some IBM/TI data link commands are not published by IEEE), but not IEEE's. A major problem is that published standards (in book form) appear at least six months to a year behind the final drafts, and IBM is influencing on IEEE 802.2 and IEEE 802.5. For example, only IBM has "reserved" 802.2 SAPs in addition to those defined by IEEE, and only IBM is trying to change the rules of the Open Systems Interconnect (OSI) model developed by the International Standards Organization (ISO), by submitting its *source routing* technique (discussed later) to IEEE 802.2 (although this, too, is expected to become a standard). This appears to be a violation of the spirit of OSI, because source routing is part of an internetworking protocol that belongs in the network layer, not the data-link layer. It is also noteworthy that, instead of using a traditional bridge, the remainder of the network-layer-routing decision is made by individual workstations; therefore, it is distributed.

A token-holding timer controls the maximum amount of time that a station can use the ring before passing on the token.

Although unconfirmed, the TI chip set is said to be capable of handling a higher-speed ring, up to 16 Mbps. Only the front-end chips are specified to 4 Mbps; the others are specified in the TMS380 user's guide as being functional to 16 Mbps. To support data rates higher than 4 Mbps, TI has only to upgrade the ring interface and ring interface controller chips; most likely, the two chips will be combined into one package. TI probably will have a one-chip token-ring controller (in plastic) available by mid-1987.

PROTOCOLS AND INTERFACES

IBM's contributions to the IEEE 802.5 standards committee forecasted the formal introduction of IBM Token-Ring products. As a result of its involvement, IBM has been the most influential company in shaping the 802.5 standard (in fact, the chairman of the 802.5 standards committee is from IBM/Raleigh).

IBM Token-Ring/IEEE 802.5 Media Access Control Protocol. The 802.5 Token-Ring Access Method and Physical Layer Specification defines the MAC sublayer of the data-link layer and the physical (signaling) protocols. Within the 802.5 specification, the frame format is defined, including delimiters, addressing, and frame-check sequences. Also defined are MAC frames, timers, and priority stacks. At the physical layer, symbol encoding and decoding, symbol timing, and latency buffering are designated. Although not part of the ISO physical-layer definition, 802.5 defines both the 1-Mbps and 4-Mbps, shielded twisted-pair attachment of the station to the medium, including the definition of the medium interface connector.

The 802.5 standard also describes services provided by the MAC sublayer to the network management and LLC sublayer, and the services provided by the physical layer to network management and the MAC sublayer. These services are defined in terms of service primitives and associated parameters, similar to the way in which the 802.2 standard is defined.

By definition, a token-ring consists of a set of *stations* connected serially by a transmission medium in which information is transferred bit by bit from one active station to the next. A station regenerates and repeats each bit, thus acting as a repeater when active. According to the 802.5 standard, a station is an entity that "serves as the means for attaching one or more devices (terminals, workstations) to the ring for the purpose of communicating with other devices on the network."

Operation. A station that has access to the medium transfers information onto

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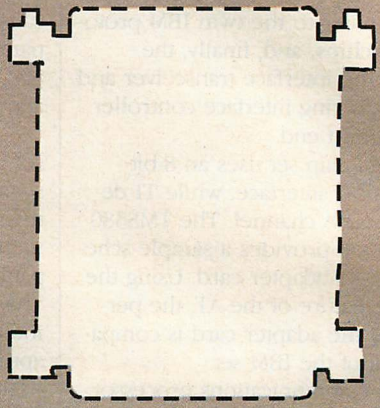

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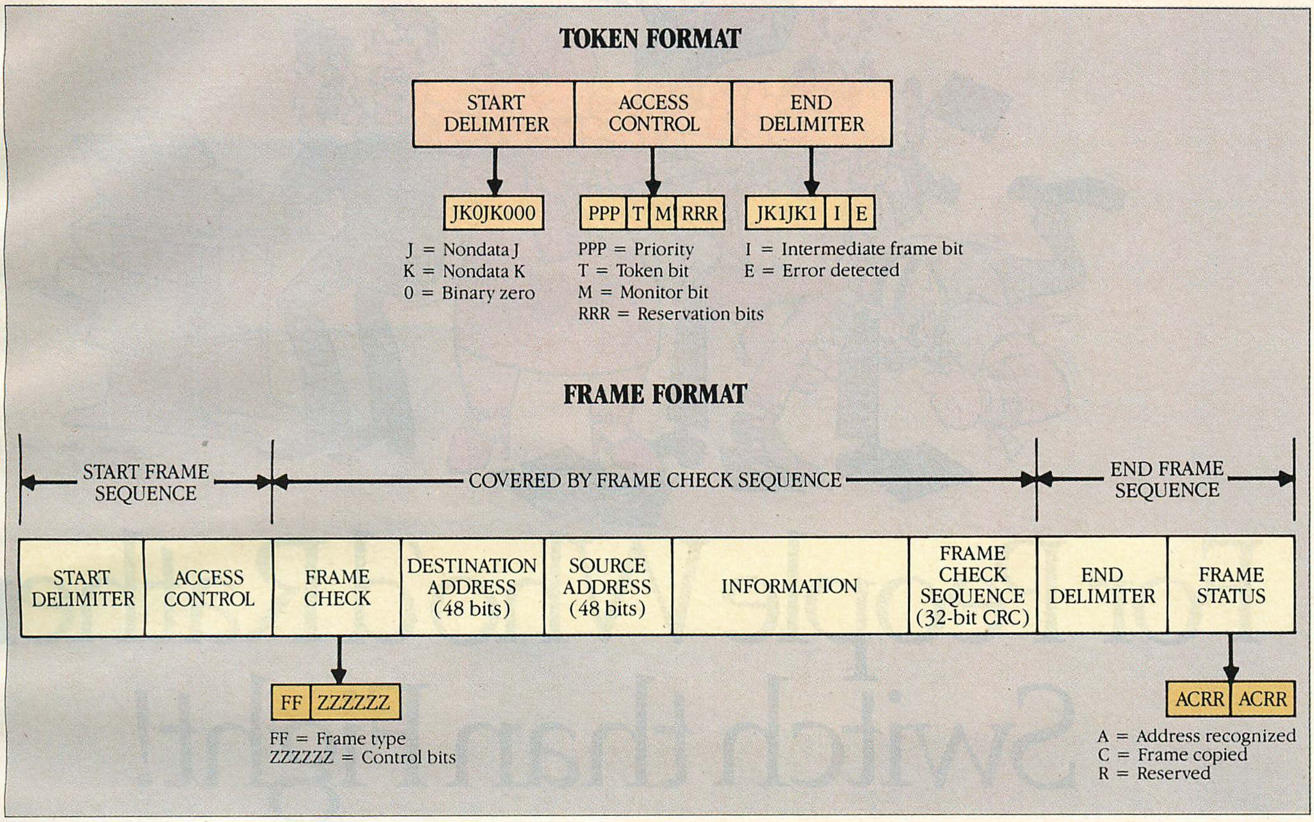
FIGURE 2: *Token Format and Frame Format*



The frame format is used for sending MAC and LLC messages to the destination station(s). The information field is optional.

the ring where it circulates from one station to the next. A station recognizes its address, and then copies the information as it passes "through" the interface. The source station that transmits the information is responsible for removing the information from the ring, preventing further circulation.

When a token is detected by a station, it may transmit its information onto the medium. When a token is "captured" by a station, it modifies the start-of-frame sequence and appends the appropriate control and status fields, address fields, information field, frame-check sequence, and the end-of-frame sequence. To make sure that all stations have fair access to the ring, a token-holding timer controls the maximum time a station can use the ring before passing the token.

Multiple levels of priority are available depending upon the class of service required, such as synchronous (3270-type data streams) and asynchronous (interactive) data transmission. An immediate network recovery has the highest priority. The allocation of priorities is performed among the stations active on the ring.

One innovative aspect of the 802.5 specification is built-in error detection and recovery mechanisms (what IBM calls the RAS, for reliability, availability, and serviceability) provided to restore network operation in the event of failed medium or medium transients (insertion and removal of stations). Detection and recovery mechanisms operate under a network monitoring function that is performed in a specific station with backup monitoring capability by other stations in the network.

Frame formats. Formats can be divided into two types: token and frames. In the accompanying figures, the formats (generally described in terms of 8-bit fields, or octets) are depicted in the sequence in which they are transmitted on the medium, with the left-most bit (the most significant bit) transmitted first.

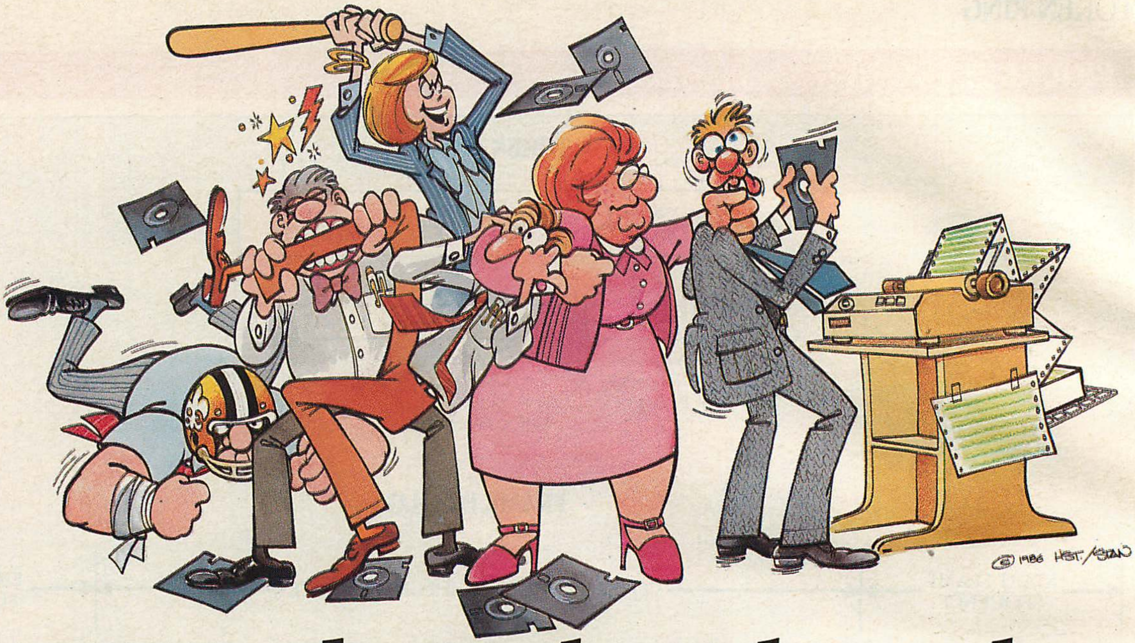
The token, the format of which is shown in figure 2, is the mechanism by which access (transmission) to the ring is passed from one station to another. The frame format, also shown in figure 2, is used for transmitting both MAC and LLC messages to the destination station(s). The information field is optional and can contain arbitrary data (that is, it does not have to contain 8-bit bytes).

The access control field contains priority bits, a token bit, a monitor bit, and reservation bits. The lowest priority is 000, the highest, 111. A token bit of 1 indicates that a frame follows. When a station wants to transmit a protocol data unit (PDU), it detects a token with a priority equal to or less than its own; it then may change the token to a start-of-frame sequence and send the PDU. The monitor bit prevents a token with priority greater than 0 or a frame from continuously circulating on the ring. The bit is transmitted as 0 in all frames and tokens, except for the monitor that inspects and modifies it.

Reservation bits allow stations to request the next token be issued at the requested priority. The station currently transmitting a frame is responsible for generating a new token at a higher priority (the PPP bits are set), and for changing the token back to the lower priority when the requesting station has completed frame transmission.

The frame control field indicates the frame type, along with control bits. When FF is set to 00, this indicates a MAC frame; 01 indicates an LLC frame; and 1x is an undefined format reserved for future use.

Each frame contains destination and source address fields. The 802.5 standard permits the field size to be either two octets (16 bits) or six octets



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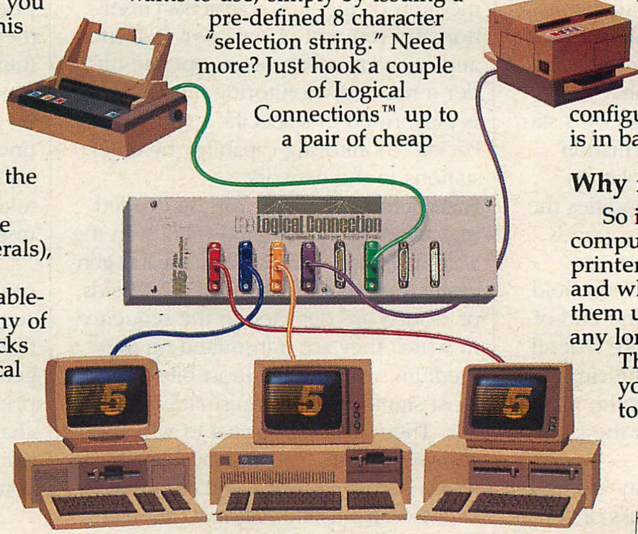

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(48 bits). The IBM Token-Ring uses six octets for addressing. If the first bit is set to 0, it is an individual address. If set to 1, it is a group, or broadcast, address (all bits set to 1).

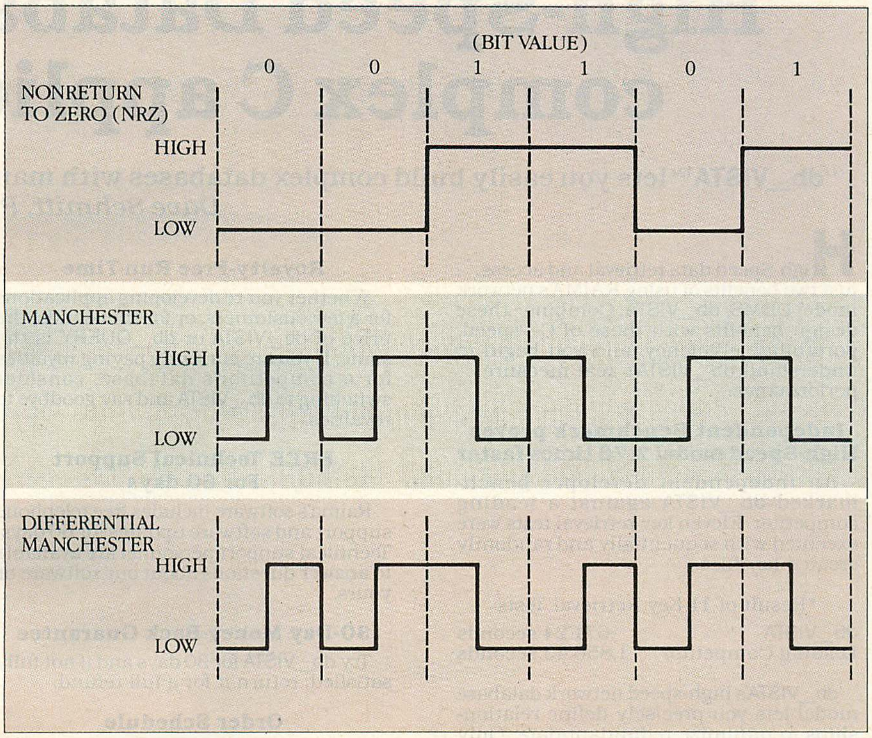
The second bit in the address field indicates whether the address is administered locally (set to 1) or universally (set to 0). The manufacturer assigns *each* station an address that is unique across the universe of LANs. (The manufacturer can obtain a set of 48-bit addresses from the IEEE; this formerly was administered by Xerox for EtherNet LANs.) On the IBM PC Adapter, this address is burned into ROM.

The frame status field contains address-recognized bits (A bits), frame-copied bits (C bits), and reserved bits. A and C bits are transmitted as 0. When the receiving station recognizes its address, it will set the A bits to 1. If it can copy the frame into its receive buffer, the C bits are set to 1. This allows the sending station to determine if the station is nonexistent or inactive on the ring; if the station is active but unable to copy the frame; or if the station is active and did copy the frame.

Physical layer. The physical layer uses *differential Manchester* encoding to transmit and detect four different symbols: a binary 0, a binary 1, a nondata-*J*, and a nondata-*K*. The *J* and *K* symbols are violations of Manchester coding: code violations allow the interface to detect delimiters, eliminating the overhead of bit stuffing (which is used in SDLC—synchronous data link control). Differential Manchester encoding is similar to Manchester encoding in that midbit transition is used to provide clocking (see figure 3). The encoding of 0 or 1 is represented by the presence or absence of a transition at the beginning of the bit period, as opposed to the midbit transition also representing the code, as is used in Manchester encoding.

Signal timing is provided by the monitor. All other stations track the frequency and phase of the incoming signal. Although the mean data signaling rate around the ring is controlled by the monitor, segments of the ring can instantly operate at speeds slightly higher or lower than the frequency of the monitor, an effect known as *jitter*. The active monitor in the adapter provides the master clock for transmission of the token. A token is sent around the ring with a transmission rate of 4 MHz. When it arrives back at the monitor, it is decoded again via the differential Manchester decoder. The time to decode the token will vary according to the amount of jitter on the ring.

FIGURE 3: *Differential Manchester Encoding*



Adapted from Data Communications Concepts

Differential Manchester encoding, like Manchester encoding, is self-clocking. The midbit transition provides both the clocking edge and the value for the bit.

The active monitor includes a time-delay mechanism called a *latency buffer* that serves two purposes. First, it ensures that enough latency bits are present on the ring so that the token can circulate continuously. At least 24 are necessary to accommodate a minimal LAN configuration of two machines: the token is 24 bits long and only one token can be on the ring at any one time. Second, it compensates for the speed and phase variations introduced in the ring. If the token speed decreases as it goes around the ring, it takes longer for the entire token to be clocked into the active monitor. The latency buffer must expand to ensure the entire token has been clocked onto the active monitor before the new token is transmitted. According to IEEE specification, the latency buffer should accommodate jitter to ± 3 bits; thus, the minimal size for the latency buffer is 27 bits. It can contract to 24 bits and expand to 30 bits to handle worst-case jitter.

IBM Token-Ring/IEEE 802.2 Logical Link Protocol. The PC Token-Ring adapter board executes functions of the LLC sublayer of IEEE 802 LAN protocol. The LLC sublayer is the upper portion of the data-link layer; it functions independently of the network-dependent MAC.

The LLC standard describes the sublayer interface service specifications to the network layer (layer 3), the MAC sublayer, and the LLC sublayer management function. This standard provides a description of peer-to-peer protocol procedures that are defined for the transfer of information and control between any pair of data-link-layer SAPs that are on a LAN.

Two classes of LLC operation are provided. Class I provides connectionless service; class II provides both connectionless, and connection-oriented service. The IBM token handler provides an interface to class II service.

Data transfer via connectionless service arranges for network entities to exchange link service data units (LSDUs) without the establishment of a data-link-level connection. The data transfer can be point-to-point, multicast (group), or broadcast (to all entities).

Connection service provides the means for establishing, using, resetting, and terminating data-link-layer connections. These are point-to-point connections between link-layer service access points (LSAPs). This service provides data-link-layer sequencing, flow control, and error recovery. Other services include connection reset (established connections can be returned to the initial state), connection termination (a network entity can request or be notified of data-link-layer connection termi-

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- Multi-user file locks clear utility
- Key file build utility
- Data field alignment check utility
- Database dictionary print utility
- Key file dump utility
- ASCII file import and export utility

*The benchmark procedure was adapted from "Benchmarking Database Systems: A Systematic Approach" by Bitton, DeWitt and Turbyfill, December 1983.

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nation), and connection flow service (provides flow control of data associated with a specified connection).

Adapter handler. All interfaces to the PC Adapter require the adapter handler, the Token-Ring Extended User Interface. TOKREUI is packaged with the adapter card on a 5¼-inch diskette as TOKREUI.COM. Its relationship to the various interfaces is shown in figure 4.

TOKREUI removes the user from the adapter's complexities, especially its complex asynchronous nature. Essentially, it provides a direct (MAC) and data-link-control (DLC) interface to the adapter. Interfacing to NETBIOS or APPC/PC requires additional software to perform MAC and DLC functions (this software is included with the NETBIOS emulator and APPC/PC).

After DOS 3.2 is booted on a PC attached to the Token-Ring, TOKREUI is invoked by entering: TOKREUI NA0, SR0, NA1, SR1. The parameters are optional; NA0/NA1 indicates node address (burned-in or locally entered), and SR0/SR1 is the shared RAM address for Adapter 00/01. Once loaded, TOKREUI occupies approximately 7KB of RAM.

If the command has been issued correctly, TOKREUI then places its entry point into interrupt 5CH. This interrupt is shared by the NETBIOS interface. Therefore, the command in the command control block (CCB) is examined. If it is less than four, then TOKREUI takes over; if it is greater than four, it may be for NETBIOS.

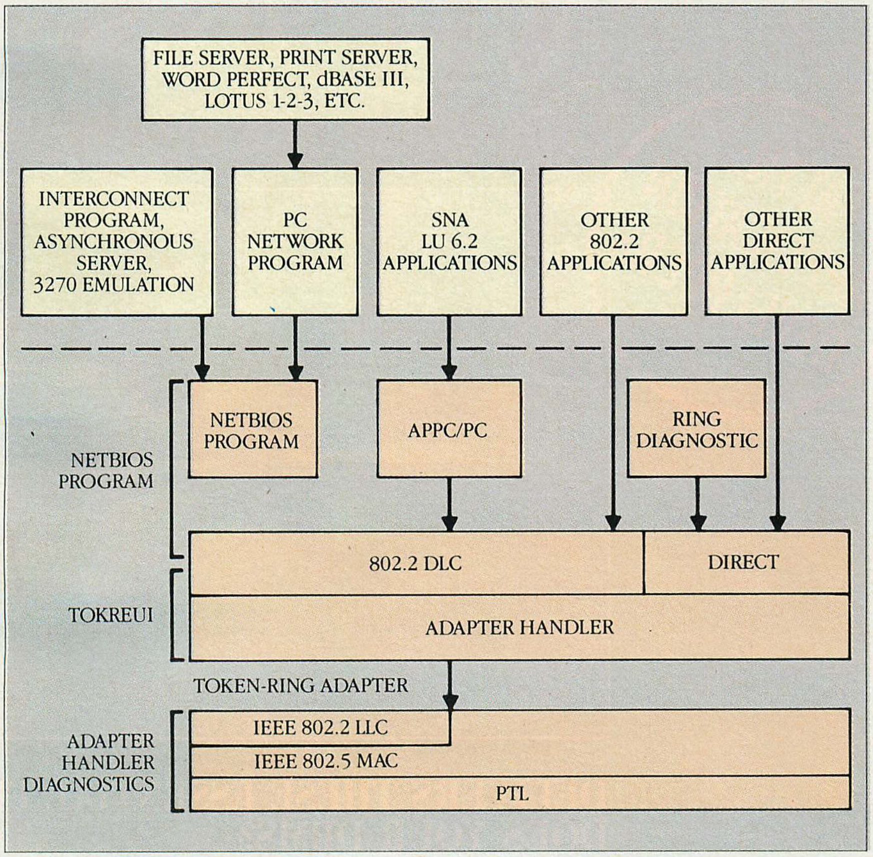
This direct interface enables the user to write a custom data-link-control procedure or, for an application, obtain error status and logs and generally to control the adapter. Primitives are included to configure and manage the adapter microcode and to support auxiliary commands to support buffer management, timers, and operational characteristics of the TOKREUI.

The data-link interface provides the IEEE 802.2 class II (connection-oriented) service interface with link-station characteristics. These include support for node hierarchy with the station component; the SAP and connect components; XID (exchange identification) and TEST commands issued on a per-SAP basis; and XID and TEST responses issued by the station component (transparent to local applications).

The SAP is an 8-bit address through which an application is identified to the DLC software. SAPs let multiple applications share the same adapter, such as APPC/PC and NETBIOS, simultaneously.

The CCB serves as the interface between TOKREUI and the application.

FIGURE 4: *Token-Ring Adapter Handler and Interfaces*



Adapted from IBM seminar material

TOKREUI, the Token-Ring Extended User Interface, provides a direct (MAC) and data-link-control (DLC) interface to the adapter. Interfacing to NETBIOS or APPC/PC requires additional software to perform MAC and DLC functions.

The application initiates a command by issuing interrupt 5CH with the PC's 8088 or 80286 EX:BX register pair pointing to the CCB. The CCB contains the adapter number (0 or 1), the command code to be executed, the return code, a pointer to the TOKREUI work area, a pointer to the CCB queue (commands can be queued), command completion address (user appendage), and an optional pointer to a list of additional parameters for some commands.

When a valid CCB is received, TOKREUI will set the return code in the CCB to FFH indicating that a command is in process. The application being used must not change the CCB until the return code is set to something other than FFH by TOKREUI.

A user appendage is an exit point to a subroutine where TOKREUI can transfer information to the application asynchronously. Information is transferred upon completion of a command or error condition, and an interrupt to the PC is generated. The appendage is entered via a CALL FAR instruction with interrupts masked off. The programmer is warned that the appendage code must be reasonably fast, or timer ticks (18.2 ticks per second) will be lost. The appendage issues an IRET to return. User appendages are needed for command completion, adapter check, and ring status check, as well as for received data, DLC change, and PC error.

TOKREUI manages buffer pools within the PC's memory, as allocated by the application. Buffer pools are associated with SAPs and are defined using the DLC.OPEN.SAP command for a given SAP or by DIR.OPEN.ADAPTER for a direct-station SAP. (After opening a SAP via DLC.OPEN.SAP, connectionless service is available. Connection-oriented services are opened by using the command DLC.OPEN.STATION; the number used depends upon the manner in which the 8KB/16KB shared RAM is allocated. A practical number of connection-oriented services is 16.)

All link stations in the ring associated with the same SAP share the same buffer pool. A link station continues to receive frames while buffers are available and when a RECEIVE command has been issued by the application. A buffer pool is required for the

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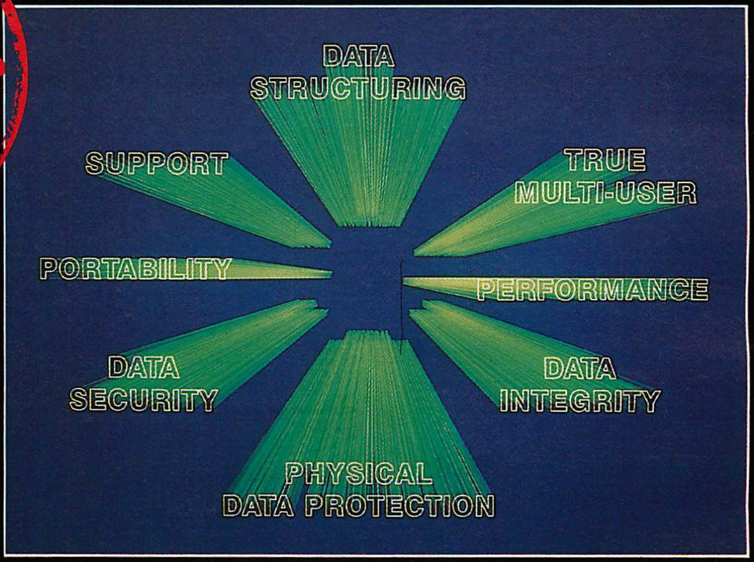

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RECEIVE command, but optional for SEND (a pool is handy, for example, in performing a "chained" send).

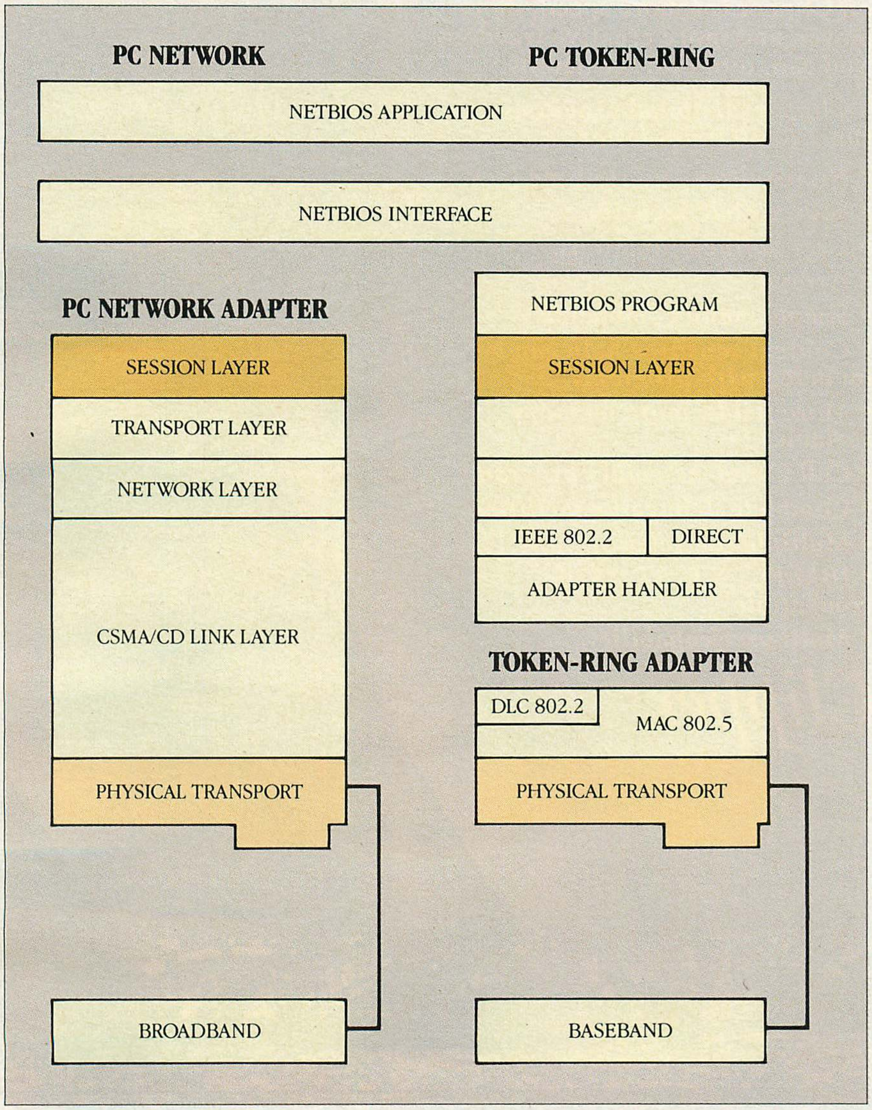
After the application issues a RECEIVE and the adapter receives a frame, the following sequence takes place: the adapter interrupts TOKREUI, which uses the BUFFER.GET code to get the appropriate number of buffers from the (SAP) buffer pool; TOKREUI moves the data from the shared RAM to the buffer(s) (if the buffer is too short, an additional buffer is requested automatically); TOKREUI exits via the user appendage defined by RECEIVE (the *received* data appendage), with the register pair ES:BX pointing to the first receive buffer (but only if the received frame fit). The frame is now in the buffer. After the application "uses" the frame, it issues the FREE.BUFFER command to free the buffer to avoid losing frames due to insufficient memory.

When an application needs to send data, it may use its own buffer space or space provided by the buffer pool (by issuing a BUFFER.GET). For efficiency in connection-oriented data transfer, the application may specify the number of outstanding transmits (by setting the MAXOUT parameter) before the transmit complete interrupt is posted. (The MAXOUT default is eight transmits.) When the transmit-complete user appendage is taken, all CCBs associated with the transmit are chained together. At this point, the following state exists: the register pair ES:BX points to the first transmit CCB issued; offset four of the CCB contains the offset of the next CCB in the chain; offset six of the CCB contains the segment of the next CCB in the chain; all CCBs in the chain are marked complete and contain the same return code value; and the user appendage taken is the command-complete appendage of the first CCB.

The initialization sequence takes up to 27 seconds for the first active adapter on the Token-Ring, and 10 to 20 seconds for each additional activated adapter. During this time, diagnostics are performed, including a self-test on the adapter hardware, a loop-back test to or from the MAU, and a check to ensure that a monitor station exists. TOKREUI makes three attempts before reporting any failure to the application.

NETBIOS. The Network Basic Input/Output System was originally developed for the IBM PC Network by Sytek. Based on Sytek LocalNet/20 protocols, it provides a session-level interface to the host, with provisions for datagram service. Supported services include peer-to-peer communications and naming.

FIGURE 5: *NETBIOS on PC Network and the Token-Ring*



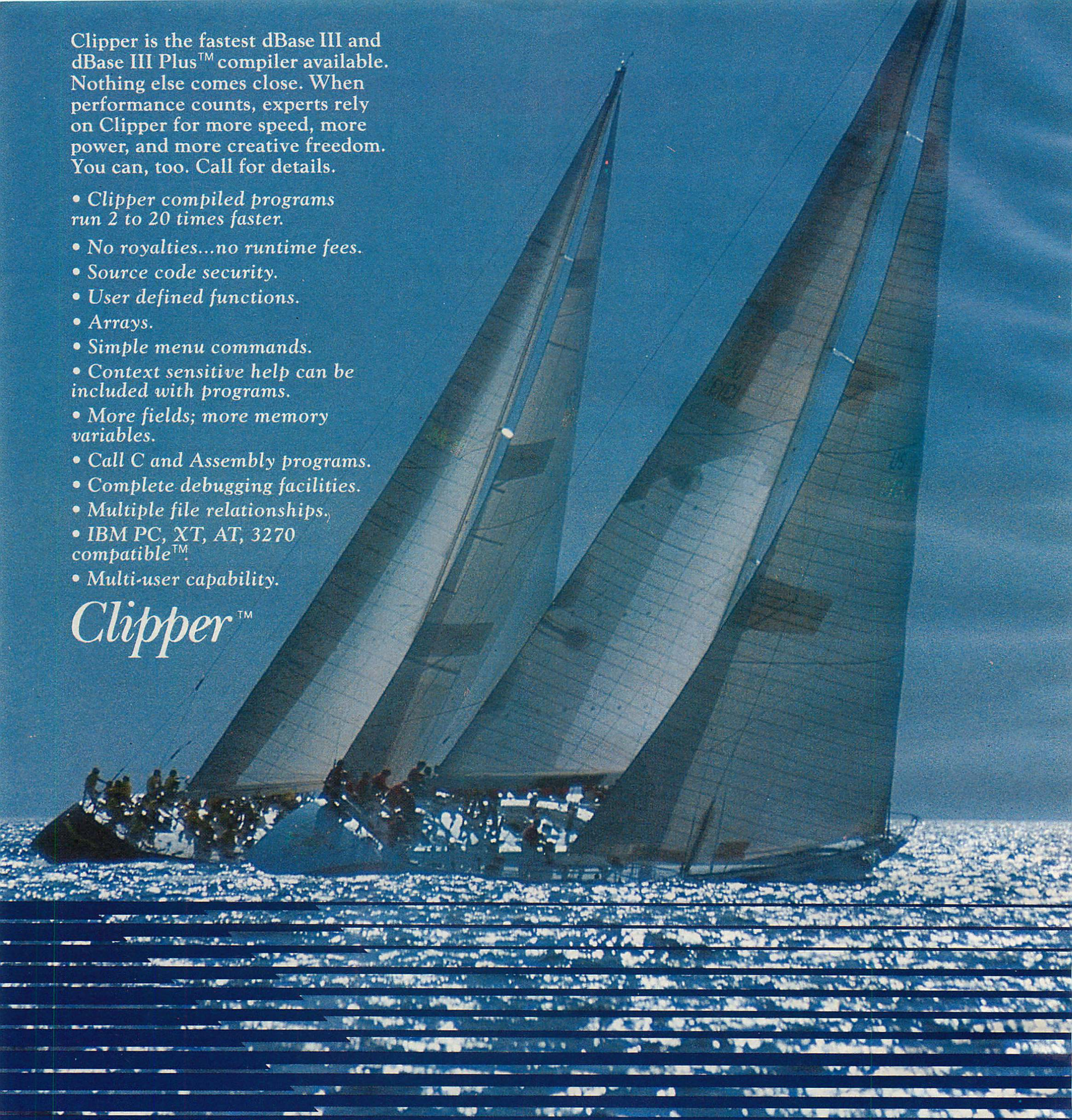
On the Token-Ring, the host processor must operate the protocols, whereas on the IBM PC Network, an on-board 80188 performs the protocol processing.

The IBM PC Network Program relies on NETBIOS for its operation, as do other programs. The Network Program implements the server message block (SMB) protocol, and provides the user with workstation functions (redirector, receiver, and messenger) and nondedicated server functions (workstation, plus server functions).

Figure 5 shows how NETBIOS is implemented in the two networks. On the Token-Ring, the host processor must operate the protocols (with NETBIOS consuming 40KB of host RAM); on the PC Network, an on-board 80188 does the protocol processing. Interestingly, IBM has shown that the Token-Ring NETBIOS implementation (in terms of raw data rate) operates faster by better than a factor of two than the PC network. This is due largely to the overhead generated among four communicating devices on the PC Network Adapter and the way in which NETBIOS protocols were programmed.

The host processor communicates with NETBIOS via the message control block (MCB); this unit is called the network control block (NCB) in the PC Network. Once the MCB is set up by the host, it interrupts NETBIOS for service. NETBIOS then takes over and invokes the necessary protocols (if required) to perform the service that is requested by the host.

The data-link layer provides the link access protocol (LAP) to the PC Network or Token-Ring. In this layer, the two networks really diverge. The Token-Ring provides IEEE 802.2 DLC and 802.5 MAC. The PC Network provides a proprietary DLC and 802.3



(CSMA/CD and frame format) MAC. LAP is used to provide service for the packet transfer protocol (PTP).

The session layer provides host access to several protocols. The session management protocol (SMP) provides support for user sessions between nodes. SMP allows users to establish connection to a named process and is responsible for interacting with the name management protocol (NMP) within the local node for determination of the named-process address. Once the destination node is determined, the initiating SMP can communicate with the SMP within the destination node to provide session-level services. In conjunction with naming, the user datagram protocol (UDP) provides support for datagrams between two names (nodes).

The NMP provides for the binding of alias names and network addresses within the entire local network. NMP performs all name management services, including the translation of remote names to a network address. This portion of the protocol is the one most responsible for the time it takes to enter a NETBIOS network: the node will broadcast its name(s) to other stations (several times to ensure reception by all other stations). Broadcasting also is performed when SMP has to establish a connection with another name.

These session-level protocols are emulated by the Token-Ring NETBIOS emulator. In the Token-Ring implementation, the protocols communicate with the adapter handler, bypassing the network and transport layers. Vendors (such as AST Research and Novell) have already developed NETBIOS emulators for non-IBM hardware using protocols that are similar to the Xerox Network Systems (XNS) protocol.

In September 1986, IBM announced NETBIOS 1.1, operating under the 3270-PC Control Program 3.0, thus bringing the 3270-PC and 3270-AT officially into the Token-Ring. This allows the PC LAN Program redirector function (with no server capability) to function in the 3270-PC. More importantly, the 3270-PC is able to communicate with a token-attached 3174 controller for access to a System/370 host. On the down side, NETBIOS increased in size to 50KB (from 40KB) and the adapter handler to 15KB (from 7KB). But this is not a problem for the 3270-PC because it supports expansion RAM beyond 640KB for applications; however, the handler must reside in the lower 640KB.

The official name for the 3270-PC adapter handler is rather long—the IBM Token-Ring Network Personal Computer Adapters Support Program 3270-PC. The handler is packaged with NETBIOS 1.1 and is slated to be available in early 1987. What sets this handler apart from the one for the rest of the PC family is that it provides an interface to the LLC functions of IEEE 802.2, thus bypassing the 802.2 supported functions on the PC Adapter (or Adapter II). Most likely, IBM will pursue this strategy with all future introductions: the RT PC adapter was first (no LLC support), followed by the 3270-PC (old adapter, but bypassing LLC support). IBM continues to enhance 802.2, making it difficult to commit to a firmware or VLSI-based implementation, as it did with the original PC Adapter and PC Adapter II.

Perhaps one of the best-kept secrets about NETBIOS is the IBM Remote NETBIOS Access Facility Program. This utility allows a remote PC to dial into a gateway PC on a Token-Ring or PC Network (via modem or IBM's ROLM CBX) and access the network resources as if the remote PC were directly attached. The gateway PC is a nondedicated PC that can handle two RS-232 ports. Vendors such as Fox Research (10-NET), Novell (NetWare Remote), and 3Com (3+ Remote) also offer this capability through their LAN software. The virtual-disk speeds, however, will be limited to 9600 bps or slower.

In September 1986, IBM announced NETBIOS 1.1, thus bringing the 3270-PC and 3270-AT officially into the Token-Ring domain.

APPC/PC. The Advanced Program-to-Program Communication is a specific implementation of the IBM System Network Architecture (SNA) LU 6.2 architecture (see "SNA Strategies," Art Krumrey, July 1985, p. 40). APPC/PC allows peer-to-peer applications to be written with PCs attached to the Token-Ring or with PCs attached to other PCs or larger IBM systems via the IBM SDLC adapter.

Essentially, a logical unit (LU) is a port through which an end user can access the SNA network to communicate with other end users or to access programs, directories, or links on other hosts. Specifically, LU 6.2 is an architecture that describes the formats and protocols for communications among distributed transaction programs in an SNA network. APPC/PC is an implementation of LU 6.2 on a physical unit (PU) 2.1 base for IBM PCs. APPC provides the means for writing applications that communicate on a peer-to-peer basis.

APPC allows this communication independently of the underlying system. It provides guaranteed delivery of data, as well as data format and session protocol transparency. No limit is set on the number of sessions or networks it can support. APPC/PC is loaded into the PC and remains resident, in the same manner as TOKREUI and NETBIOS. A PC application accesses APPC services through DOS interrupt 68H. The SAP assigned to APPC is 04H (F0H is assigned to NETBIOS).

An application converses with APPC using *verbs*. Verbs are parameter lists containing supplied parameters, returned parameters, and return codes. The parameters are supplied in an application-supplied buffer with the register pair DS:DX pointing to the first byte in the buffer. Interrupt 68H is then issued. Return parameters and return codes are generated by verb execution. Verbs fall into five categories: control, mapped conversation, basic conversation, network management, and other.

Control verbs set up and manage communications with another program. Mapped conversation (MC) verbs are issued by transaction programs that are the final users of the data exchanged. Basic conversation verbs are issued by LU service transaction programs, which provide services and exchange data for their transaction programs. A network management verb provides management services information to the local node and/or another node (a host, for example), which provides network problem determination. It can be used to provide ring and adapter failure information to the SYSLOG.

Still other verbs are used to define a user's own verbs using the same interrupt vector (68H) as APPC/PC. For example, the CONVERT verb is convenient for PC-to-large-host applications because it converts between the ASCII and EBCDIC character sets. TRACE provides a tracing of application program interface (API) invocations and messages that are sent or received. TRACE can log to any DOS device. The verbs DISABLE/ENABLE_APPC control the operation of APPC, which must be disabled while performing another DOS function call. If not disabled, the PC may hang up if an APPC operation is interrupted.

APPC/PC consumes more than 160KB of RAM. An additional 21KB are

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SERVICES AND APPLICATIONS

With the proper protocols and interfaces in place, the IBM Token-Ring provides a rich environment for a variety of software-supplied services and applications—some were introduced in conjunction with the new network and some were previously established.

IBM PC Local Area Network Program. The original IBM PC Network Program was designed to operate with DOS 3.1 and NETBIOS on the PC Network. To operate the program on the Token-Ring, the NETBIOS emulator and DOS 3.2 are required. The installation procedure is menu driven, and, once installed, the PC LAN Program can be operated by typing commands at the DOS prompt or via menus.

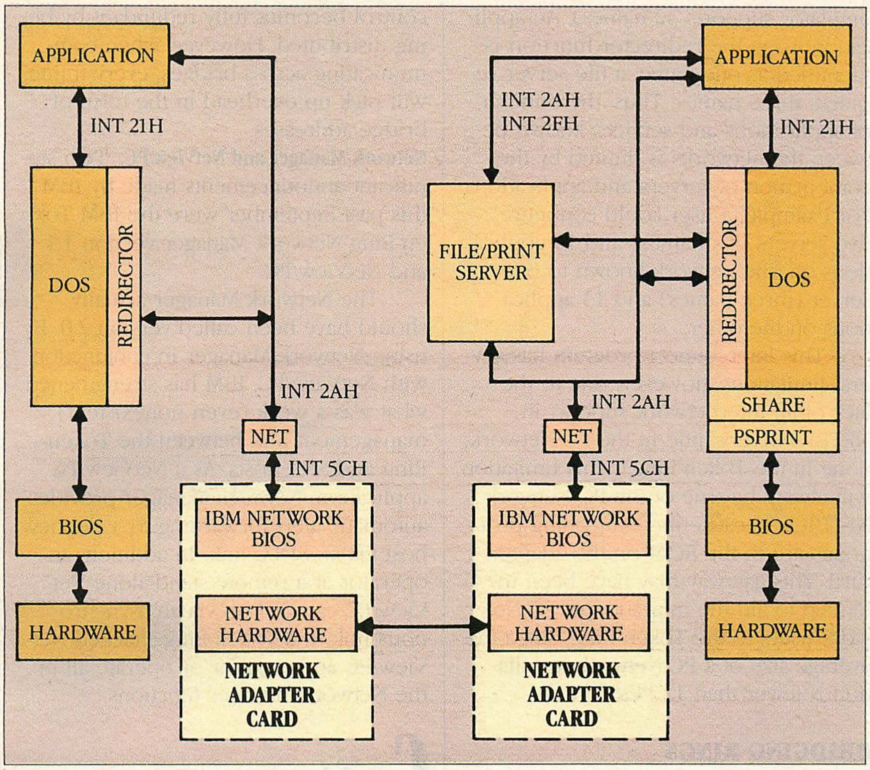
The PC LAN Program consists of a single executable file that can be called up in four ways: after the NET START command is executed, the user specifies a redirector, receiver, messenger, or server. The first three are for workstations, the last selection is a true, nondedicated file/print server implementation that runs as a background task in a workstation. Depending upon its configuration, the PC LAN Program can use from 30KB to 186KB of RAM.

The redirector provides the most basic route to gain access to the local network. It intercepts the workstation's printer and disk I/O to send to a server; users also can send messages to other machines. The receiver, messenger, and server perform in a manner similar to the redirector, but with these added services: the receiver receives and logs messages to any device or file, the messenger allows a user to transfer files, and the server allows hard disks and printers to be shared.

Figure 6 presents a technical overview of DOS 3.2 and NETBIOS operation. It illustrates how DOS service interrupt 21H is intercepted, and, if necessary, how the interrupt is redirected over the network via the NET program to a server to perform an operation. An application can also bypass the NET program by issuing its own NETBIOS commands via interrupt 5CH.

This figure points out a major performance drawback to the IBM PC LAN Program: the server is dependent upon DOS for control of the shared resources. DOS was not designed to function as a server (even DOS 4.0, with its multitasking capabilities, must use the same FAT, storage, and so on). In response, vendors such as 3Com and Novell have designed proprietary software (operating systems) and/or hardware to function as a file server.

FIGURE 6: *DOS 3.2 and NETBIOS Redirection*



Adapted from IBM seminar material

An application can bypass the NET program by issuing its own commands via interrupt 5CH, rather than being "well behaved" and using interrupt 2AH.

Asynchronous Communications Server. This is a major new service introduced by IBM with the Token-Ring. The server (a PC) provides access to and from the network via two switched lines (per server) connected to a modem or IBM/ROLM CBX. It requires NETBIOS for its operation, and works with the Token-Ring and the IBM PC Network.

The server program runs in either a dedicated or a nondedicated PC. It allows specially programmed applications operating on the network to dial out from the network or outside applications to dial in to the network. The network must include a complementary application to service the incoming call. The server is a program and protocol specification only—on its own it does nothing. For example, IBM does not provide a network terminal emulation package that runs on a workstation and communicates with the server. The user or third party must supply the necessary applications software. Two applications can be set up as servers and communicate with each other via the LAN. This is useful for debugging new communications server applications in which one server must provide "dummy" communications with another (acting as an application). Some vendors, including Microstuf (Crosstalk) and Software Publishing (PFS:Access), have adapted their programs to work with the server.

Token-Ring/PC Network Interconnect Program. The Interconnect Program allows a dedicated PC to act as a gateway between the Token-Ring and PC Network or two PC Networks. A PC running only the interconnect program is physically attached to the two networks with one Token-Ring adapter card and one PC Network adapter card. Applications written to NETBIOS can communicate with devices on either network.

An IBM PC Network Program user, for example, can access programs or data on a server from one network to another. This requires the Interconnect Program to be preconfigured to identify the devices (or names) on each network that will be known to the other. The names cannot be dynamically changed during operation. The gateway receives messages from one network and forwards the messages to the other; an operator also can check device status and monitor gateway activities.

As many as 16 names for each network can be defined to the interconnect program (this is a limitation of the

NETBIOS implementation on the PC Network—the Token-Ring NETBIOS emulator supports 32 names). An application using the redirector function is identified as one name; a file server requires three names. Thus, the number of applications and services known between the networks is limited by the combination of servers and applications. For example, a user could configure two servers (six names) and 10 applications on one network known to one server (three names) and 13 applications on the other.

This interconnect program has several limitations, however, due to the lack of an internetwork support in NETBIOS (very little in the PC Network, none in the Token-Ring). This limitation will always be true of the PC Network NETBIOS because the controlling programs are in the ROM on the adapter card. This gateway may have been intended to aid the migration of PC Network users to the Token-Ring, since the average size of a PC Network installation is fewer than 12 PCs.

BRIDGING RINGS

Multiple rings can be bridged together via the IBM Token-Ring Network Bridge Program, which requires a dedicated AT with two Adapter II cards. Communications between PCs across the bridge are transparent to applications. The rings operate independently (each ring passes its own token), but work together as one logical ring. More than 72 devices (using type-3 wire) or more than 260 devices (using data-grade wire) can be interconnected.

The bridging program is not limited, as is the interconnect program. The PC LAN Program or any application can operate across one or more rings. The bridging function is performed using a superset of the 802.2 LLC functions: the IBM source routing technique mentioned previously.

A route is determined by broadcasting an XID (exchange identification) or TEST frame throughout the network. Bridge addresses accumulate in the frame as it passes around the network. Multiple responses may be received by the originating PC if more than one bridge exists between it and the destination PC. The originating PC must decide which route to use, typically the first response received. In general, a frame can be given one of four routing directives: broadcast to this ring segment, limited broadcast, general broadcast, or point-to-point routing.

The advantages of source routing are that the bridges do not need translation tables to function and do not have to make routing decisions; routing control becomes fully redundant by being distributed. However, when communicating across bridges, every frame will pick up overhead in the form of bridge addresses.

Network Manager and NetView/PC. Two significant announcements made by IBM this past September were the IBM Token-Ring Network Manager version 1.1 and NetView/PC.

The Network Manager actually should have been called version 2.0. By using Network Manager in conjunction with NetView/PC, IBM has strengthened what was a weak (even nonexistent) management link between the Token-Ring and SNA hosts. As a NetView/PC application, Network Manager provides automatic alert forwarding to a NetView host via an SDLC link. In addition, an operator at a remote stand-alone NetView/PC can dial up via an asynchronous link to a Token-Ring-attached NetView/PC and monitor or operate all of the Network Manager functions.

Could NetView/PC mean the end of DOS? At a cost of $2,000 per PC, NetView certainly will not be replacing DOS in the near future.

Version 1.1 lives up to its billing as a manager; version 1.0 was more of a diagnostics program. Version 1.1 retains 1.0 features such as monitoring of the ring for hard (disruptive) and soft (intermittent) errors, logging of errors to disk or printer, and identification fault domains. Clearly, IBM wants to strengthen the SNA family by extending it to the PC. NetView/PC is actually a complete multitasking operating system for the IBM PC family. DOS merely runs as a task under NetView/PC.

NetView is an implementation of the service point in the newly announced IBM Open Communications Architecture. It is the base upon which device-dependent applications will be built to support the Token-Ring and Voice (ROLM CBX) networks. The Network Manager 1.1 is such an application, as is the new NetView/PC ROLM Call Detail Recorder.

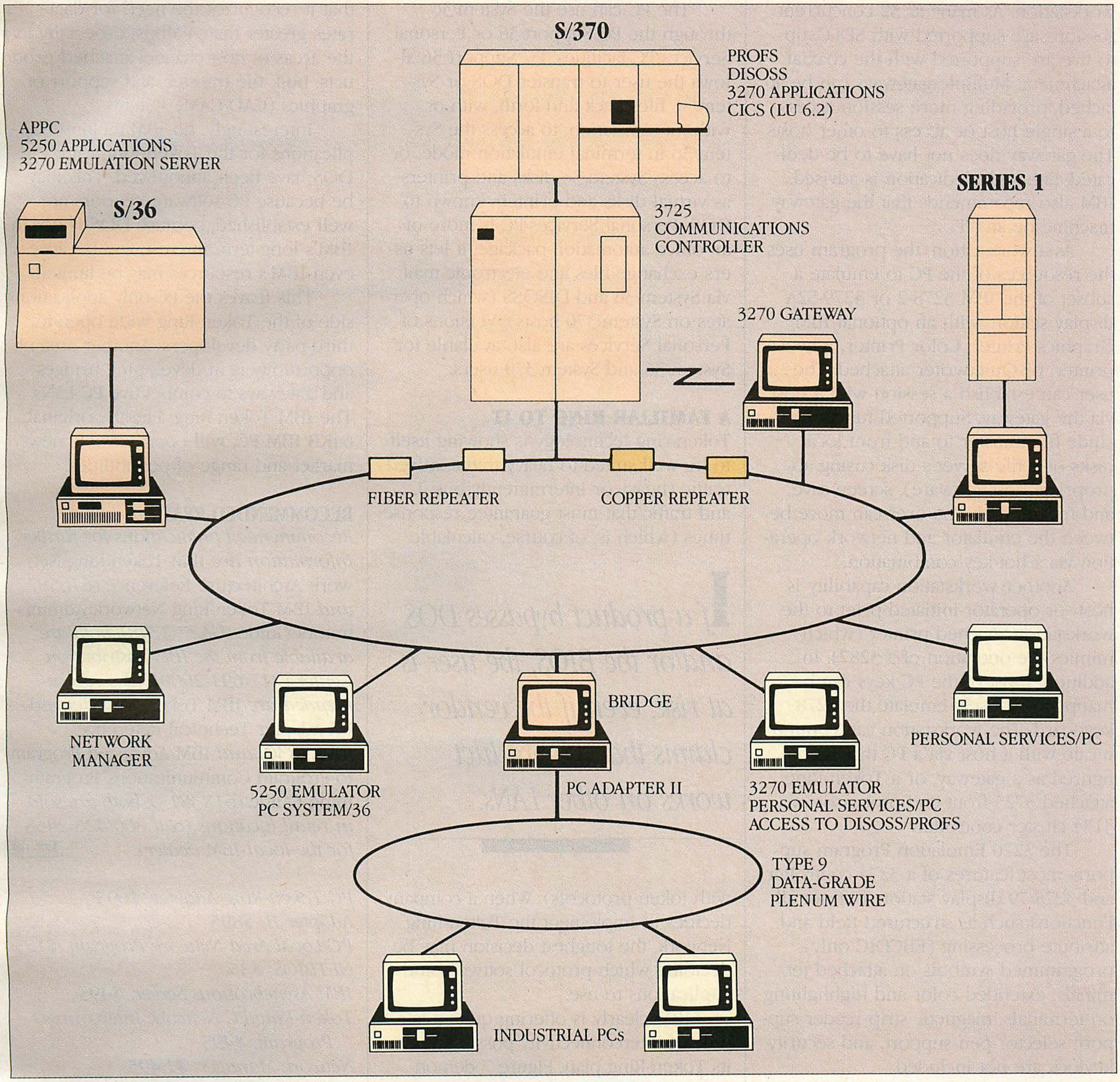
Several facilities are available through NetView: The Alert Manager stores alert data with (optional) automatic sending to a NetView host. The Problem Manager permits a user to create, delete, or modify network problem information. The Service Reminder is an "alarm clock" that reminds operators to perform tasks such as network configuration changes and backing up PC file servers. The Remote Console Support allows remote operation of NetView/PC. The Communications Manager consists of APPC (LU 6.2) services, SNA PU services, and services required to communicate to remote devices over an RS-232 link (such as the ROLM Call Detail Recorder), either asychronously or using SDLC. An Application Programming Interface/Communication Services (API/CS) interface also is included to develop device-dependent applications for operation with NetView/PC.

Could this be the end of DOS? At $2,000 per PC for NetView/PC, the end will not come in the near future. True, the user gets a lot of SNA functionality for the money, but the vast majority of installed PCs (and clones) are not connected to SNA hosts. Eventually, however, it just may happen—a subset of NetView/PC could do away with DOS.

Third-party software. Most third-party, multiuser software that was designed to operate with NETBIOS and/or DOS 3.1 or later will function properly in the Token-Ring under DOS 3.2. Beginning with DOS 3.0, IBM and Microsoft added extended functions to support byte-range locking within a file and new file-open modes to facilitate file sharing. These added functions are needed to support database-oriented applications and stand-alone applications (so they automatically lock files in use) in a network environment, but these functions are inadequate for developing servers and distributed applications. For example, DOS 3.x has no interprocess communications or semaphores, facilities that have been added to DOS 4.0.

Many popular software packages will not operate properly on the Token-Ring, or in some cases, on any LAN at all. In nearly every case, the problem lies with the software. A program may not be well behaved or perhaps was not developed with consideration of its use on a LAN. Lotus 1-2-3, for example, reads a spreadsheet file into memory, then closes it while the user is working on it, thus leaving the file at the mercy of other users. dBASE III, in theory, should work properly on the Token-Ring because it works with PC Network under the PC LAN Program and NETBIOS, as well as on Novell NetWare-based LANs. But it does not: dBASE

FIGURE 7: *IBM Token-Ring Attachments*



A variety of machines can be attached to the IBM Token-Ring Network. It also is possible to link several rings through a bridge.

III is not a well-behaved program, bypassing both DOS and the NETBIOS.

The first step is to make certain a multiuser application or development product (such as a database manager) uses the extended DOS file-sharing facilities. If it uses NETBIOS, it should be tested: the NETBIOS timing is different on PC Network than it is on the Token-Ring. If a product bypasses DOS and/or the BIOS, the user is at risk, even if the vendor says it works on other LANS such as NetWare, 3Com, or the IBM PC Network; it may not function properly on the Token-Ring. Users should look for vendor certification that the product works on the Token-Ring; although these may not number many as yet, the field surely will increase in time.

CONNECTING TO LARGER HOSTS

Connectivity to larger IBM computing entities is one of the great draws for IBM PC networks. The easier this connection is made, the more likely a network will be successful.

3270 Emulation Program. This program provides users on the Token-Ring access to IBM hosts from their workstations, without the need for dedicated coaxial wiring and SDLC cards on each workstation that desires host communications. (For a discussion of 3270 emulation, see "Emulating the 3278," Roger Addelson, February 1986, p. 48.)

Because it was written originally for the PC Network, this program relies on NETBIOS for operation. It allows the PC to be operated in one of three modes: as a gateway on the network, as a workstation on the network, or as a stand-alone remote user station.

As a gateway on the network, the PC requires the IBM SDLC card (for remote 3274 operation) or IBM 3278/79 coaxial adapter board (for distribution function terminal, or DFT, operation) to communicate with the host. The gate-

way then serves users on the network who are running the program as a workstation. As many as 32 concurrent sessions are supported with SDLC; up to five are supported with the coaxial attachment. Multiple gateways can be attached, providing more session access to a single host or access to other hosts. The gateway does not have to be dedicated, although dedication is advised. IBM also recommends that the gateway machine be an AT.

As a workstation, the program uses the resources of the PC to emulate a subset of the IBM 3278-2 or 3279-S2A display station, with an optional IBM Graphics Printer, Color Printer, Wheelprinter, or Quietwriter attached. The user can establish a session with a host via the gateway. Supported functions include file transfer to and from local disks or a file server's disk (using appropriate host software), screen save, and file append. The user can move between the emulator and network operation via a hot-key combination.

Another workstation capability is host- or operator-initiated print to the workstation-attached printer (which mimics the operation of a 3287). In addition, most of the PC keys can be mapped to closely emulate the 3278 keyboard. The workstation can communicate with a host via a PC that is configured as a gateway, or a Token-Ring-attached 3725 front-end processor or 3174 cluster controller.

The 3270 Emulation Program supports most features of a 3274 controller and 3278/79 display station, but not all. Functions such as structured field and attribute processing (EBCDIC only), programmed symbols on attached terminals, extended color and highlighting on terminals, magnetic strip reader support, selector pen support, and security keylock are not included.

System/36. A System/36 model 5360 or 5362 can be attached to the Token-Ring using the IBM System/36 Local Area Network Attachment Feature with the System/36 PC 5360/5362 LAN Communications Licensed Program and the model 5364 with the System/36 PC 5364 Local Area Network Licensed Program. All models can connect to a maximum of two rings. The System/36 Token-Ring products are scheduled to be available in the second quarter of 1987.

The 5360/62 attachment consists of a direct-attach System/36-to-AT adapter installed in a dedicated AT that is connected to the Token-Ring via the Adapter II. For the 5364, also known as the System/36 PC, the AT is attached directly. In either configuration, a communications program is downloaded into the AT from the System/36.

The PC can use the System/36 through the PC Support/36 or Personal Services/PC facilities. PC Support 36 allows the user to transfer DOS or System/36 files back and forth, with or without translation, to access the System/36 in terminal emulation mode, or to access System/36 disks and printers as virtual disks and printers known to DOS. Personal Services/PC is more of an office automation package; it lets users exchange files and electronic mail via System/36 and DISOSS (which operates on System/370 hosts). Versions of Personal Services are also available for System/36 and System/370 users.

A FAMILIAR RING TO IT

Token-ring technology is showing itself to be well suited to heavy traffic, mixed traffic (heavy or intermittently busy), and traffic that must guarantee response times (which is, of course, calculable

If a product bypasses DOS and/or the BIOS, the user is at risk, even if the vendor claims that the product works on other LANs.

with token protocols). When a company decides to implement the Token-Ring Network, the toughest decision may be deciding which protocol software and applications to use.

IBM clearly is offering quite a latitude of interconnectivity possibilities in its Token-Ring plan. Figure 7 demonstrates some of these connections. At the same time, it is allowing for great flexibility among third-party vendors in developing products. Thus, the end user can have the best of both worlds.

While the Token-Ring already boasts a great deal of integrity (via MAU operation and recovery features of the 802.5 protocols), IBM has begun to fill the need for diagnostics and management tools (a missing element of many PC LANs) via the Network Manager and NetView/PC programs. Future IBM products will provide more management capabilities to control the operation of other rings from a single location.

Interconnectivity will increase with channel-attached host and ROLM CBX connections. IBM has guaranteed 16-Mbps performance on installed Token-Ring data-grade wire, and has stated that it recognizes the need for data rates greater than 4-Mbps, especially in the areas of host channel-attached products, bulk file transfer, and support of graphics (CAD/CAM) systems.

Interestingly, no IBM multiuser applications for the Token-Ring using DOS have been announced. This may be because PC software vendors are well established, because DOS is not in IBM's long-term interest, and because even IBM's resources may be limited.

This leaves the PC-only applications side of the Token-Ring wide open for third-party developers. Another area of opportunity is in developing bridges and gateways to competitive PC LANs. The IBM Token-Ring, like the original 64KB IBM PC, will open a whole new market and range of possibilities.

RECOMMENDED READING

Recommended publications for further information are IBM Token-Ring Network Architecture Reference *(6165877) and* IBM Token-Ring Network Administrators Guide *(GA27-3748); both are available from the IBM Distribution Center (717/691-2000). Also recommended are* IBM Token-Ring Network PC Adapter Technical Reference *(69X7830) and* IBM Advanced Program-to-Program Communications Programming Guide *(61X3813); both are sold in retail locations (call 800/426-2468 for the local IBM dealer).*

PC Token-Ring Adapter, $695
Adapter II, $895
PC Local Area Network Program, $125
NETBIOS, $35
IBM Asynchronous Server, $495
Token-Ring/PC Network Interconnect Program, $495
Network Manager, $1,495
NetView/PC, $2,000
3270 Emulation Program, $475
System/36 Local Area Network Attachment Feature, $2,500
System/36 PC 5360/5362 LAN Communications Licensed Program, $925
System/36 PC 5364 LAN Licensed Program, $695
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Information Systems Group
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J. Scott Haugdahl is a senior systems specialist at Architecture Technology Corporation, a consulting, publications, and seminar firm specializing in data communications.

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MICROSOFT C 4.0 *A Great C Battle Rages and You're Winning*

As the dreadnaughts pound each other with ever heavier ordnance, today's programmers reap the spoils of this war. Bundling a source debugger and a "make", and sporting a "huge" memory model permitting single data objects larger than 64k, the Microsoft C compiler has jumped a full version number to 4.0. But what's really impressive are the benchmarks reported in Dr. Dobb's (8/86) encyclopaedic survey of 17 C compilers. Microsoft's and IBM's C (licensed from Microsoft) run away with the contest winning 11 of 27 benchmarks.

The CodeView™ debugger, free for a limited time, uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows—use a mouse if you like—obviate learning of commands. "A source-level debugger that puts the rest to shame" (Dobb's).

Microsoft C now has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips. A big plus in multi-language settings: call from this C any routine written in later versions of M'soft Pascal, FORTRAN, or Macro Assembler. Object code of all four may be intermixed come link time or commingled into libraries.

Both linker and library manager are part of the package, as is the "make", a UNIX™ name for a smart batch program which knows to expend minimum effort to rebuild any size of project by compiling and assembling only elements affected by new or changed modules.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

Ask for:	List:	PC Brand:
G0500	$450	$295

C-TREE *B-Tree File Manager, Source Code, No Royalties!*

C-tree is sturdy code that has weathered many seasons of prolonged and widespread use. It comes in C source, so you can modify it to fit a special case. No royalties provided you bind it into your binary application.

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C-tree permits any number of keys for a data file, supports duplicate keys, alphanumeric or numeric, supports files of variable record length; multiple keys in one index file, and keys of variable length. Both high level ISAM routines which handle details with minimum coding, and decomposed step-by-step functions you can access directly. It's comprehensive.

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Versions:	List:	PC Brand:
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L0III For dBASE III	$250	$195
LCIII With Source	$500	$390

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Storyboard Your Program

The Legendary One has created Metaphor Two when the rest of us are still on Zero. Dan's first was the original electronic spreadsheet (VisiCalc™). This one is for programmers.

Words don't express program ideas because programs are screens! Dan's Demo creates slide shows. Create a screen — a snapshot of your planned product as it runs. Anything goes: words, borders, box rules, inverse and underlining of monochrome, fore- and background color. Copy this "slide" to an empty screen. Change it a little, to show the next instant of run-time. Do it again. Presto, a whole slide show of your program in action.

All 250 characters and attributes are available from scrollable lists which pop to the screen. All commands are layered in Lotus-style pop-up menus. Frequent choices mapped to function keys as well. 80x25 character mode, not bit-mapped.

Screen areas can be blocked for cut and paste or filled with color or characters, even blink. Slides can overlay on others, can be shuffled, deleted. Slides can proceed at time intervals or branch anywhere in the slide sequence depending on user keyhits.

Invaluable to prototype the program you are about to write, to position the labels, choose the color decor, smoothe out the keystroke interface. Or load the "capture" utility and snapshot the screens of any running program for an instant slide show.

Each copy entitles you to redistribute fifty of the slide projector program that runs demos. Plain manual, no binder keeps price of big product small. "Might... become *the* essential tool in...user interface prototyping," *Tech Journal.* Ask for: N0100. List: **$75** US: **$69**

BASTOC *OPTIMIZES!*

Translates BASIC Into C

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Lattice 3.0. It will optionally convert your program into a single monolithic C function or decompose it into separate functions, one for each GOSUB label.

Version 2's optimization dramatically reduces execution time. Converts to integers those variables in BASIC programs which do not need floating point. Where BASIC uses full assignment statements to increment counters, BASTOC converts to C's compact form. Strings dynamically allocated ridding your application of BASIC's catatonic halts for garbage collection. Creates structure of even convoluted BASIC code. Huge worksaver.

Ask for:	List:	PC Brand:
S0375	**$495**	**$399**

Shopping List for the Power Workbench

ASSEMBLERS & DEBUGGERS	LIST	OURS
Advanced Trace-86 *Morgan, ASM Interpreter*	175	**149**
Codesmith-86 *Debugger by Visual Age*	145	**109**
Cdebugger *by Micro-Software Developers*	165	**139**
CSD Debugger *C source level by Mark Williams*	75	**75**
C-Sprite Debugger *by Lattice, source level*	175	**139**
Microsoft Macro Assembler *with Utilities*	150	**109**
PASM86 *by Phoenix, Macro Assembler*	195	**144**
Periscope I Debugger *Data Base Decisions*	295	**269**
Periscope II *Data Base Decisions*	129	**111**
Pfix86 Plus *by Phoenix, Symbolic Debugger*	395	**279**
BASIC LANGUAGE		
BetterBASIC *Summit Software*	195	**165**
BetterBASIC Utilities *8087 Math Support*	99	**85**
Btrieve Interface	99	**85**
Run-Time Module	250	**225**
Microsoft BASIC Interpreter *for XENIX*	350	**295**
Microsoft QuickBASIC Compiler *full BASICA*	99	**79**
Professional BASIC *by Morgan*	99	**79**
RM/BASIC *by Ryan-McFarland*	600	**480**
True BASIC *True BASIC Inc*	150	**119**
Run Time Module (Price slashed)	150	**119**
True BASIC Libraries *Btrieve, Asyn, Sort, etc.*	Var	**Call**
C COMPILERS		
C-86 Compiler *Computer Innovations*	395	**289**
Lattice C Compiler *from Lattice*	500	**299**
Let's C Compiler *by Mark Williams*	75	**69**
with CSD Source Level Debugger	150	**129**
MWC-86: Mark Williams C Development	495	**369**
Microsoft C Compiler *4.0*	450	**295**
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	**249**
Instant C *by Rational Systems*	500	**395**
Interactive-C *by IMPACC with debugging*	249	**219**
RUN/C Professional *from Lifeboat*	250	**185**
RUN/C *without Loadable Libraries*	120	**109**
TEXT EDITORS		
Brief *from Solution Systems*	195	**Call**
Epsilon *by Lugaru Software, like EMACS*	195	**169**
FirsTime *by Spruce Technology, C syntax*	295	**229**
Kedit *by Mansfield, similar to Xedit*	125	**115**
LSE, the Lattice Screen Editor *Multi Window*	125	**100**
Pmate *by Phoenix, with Macros*	195	**149**
Text Management Utilities *Grep, splat, diff, etc.*	120	**100**
Vedit *by Compuview*	150	**119**
Vedit Plus *by Compuview*	225	**180**
FILE MANAGERS		
Btrieve *by Softcraft, no royalties*	250	**195**
Btrieve Network *by Softcraft*	595	**465**
c-tree *by FairCom — no royalties, source*	395	**329**
dBC *dBASE file manager from Lattice*	250	**195**
with source	500	**390**
dbVista *single user DBMS by Raima*	195	**159**
dbVista *multi-user DBMS*	495	**429**
Opt-Tech Sort *Can sort Btrieve files*	149	**119**
SCREEN MANAGEMENT & DESIGN		
Curses *by Lattice, UNIX screen designer*	125	**99**
with Source	250	**199**
Greenleaf DataWindows *New*	225	**169**
with Source simultaneously	395	**297**
Source purchased later	225	**169**
On-Line Help *from Opt-Tech Data*	149	**119**
Panel *by Roundhill, no royalties*	295	**229**
View Manager for C *by Blaise*	275	**209**
Vitamin C *by Creative Programming*	150	**139**
Windows for C *Vermont Creative Software*	195	**149**
Windows for Data *includes Windows for C*	295	**259**
ZView *Data Management Consultants*	245	**199**

GRAPHICS	LIST	OURS
Essential Graphics *by Essential, no royalties*	250	**210**
GSS Graphics Development Toolkit	495	**375**
GSS Kernel System *by Graphic Software*	495	**375**
GSS Kernel System *for IBM RT*	795	**645**
GSS Metafile Interpreter	295	**235**
GSS Plotting System	495	**375**
Halo Graphics Kernel System	300	**219**
with Dr. Halo II, by Media Cybernetics	440	**299**
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	**149**
Greenleaf Communications *by Greenleaf*	185	**139**
PTel *by Phoenix, Binary File Communicator*	195	**149**
Software Horizons Pack 3	149	**119**
UTILITY LIBRARIES		
Blaise C Tools Plus	175	**149**
Blaise C Tools	125	**109**
Blaise C Tools 2	100	**89**
C Food Smorgasbord *by Lattice*	150	**109**
C Utility Library *by Essential, 300 functions*	185	**139**
Greenleaf Functions *by Greenleaf Software*	185	**139**
PforCe *by Phoenix, vast library*	475	**349**
Software Horizons *Packages*	Var	**Call**
TopView Tool Basket *by Lattice, source avail*	250	**199**
DEVELOPMENT TOOLS		
Code Sifter *by David Smith Software, Profiler*	119	**99**
C-Worthy *by Custom Design Software*	295	**269**
C-Worthy for Network *Menus, help, errors*	495	**449**
Dan Bricklin's Demo Program *Prototyper*	75	**69**
LMK from Lattice *by Lattice, "make" like UNIX*	195	**149**
Microsoft Window Development Toolkit	500	**365**
PC-Lint *by Gimpel Software, after UNIX's "lint"*	139	**125**
PFinish *by Phoenix, EXE performance analyzer*	395	**279**
Plink86 Plus *Utilizes memory for overlays*	495	**359**
Pmaker *by Phoenix, like UNIX "make"*	125	**105**
Pre-C *by Phoenix, UNIX "lint"-alike*	295	**208**
Pfantasy Pac *six Phoenix products*	1295	**895**
OTHER TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	**399**
BASIC-C *BASIC's functions added to C*	175	**139**
The HAMMER *by OES Systems*	195	**179**
Report Option *by Softcraft, Btrieve Report Gen.*	145	**128**
Xtrieve *by Softcraft, Query Utility for Btrieve*	245	**220**
FORTRAN COMPILERS & UTILITIES		
ACS Time Series *by Alpha Computer Service*	495	**469**
Forlib- Plus *by Alpha Computer Service*	70	**59**
Microsoft FORTRAN *Links with Microsoft C*	350	**219**
Microsoft FORTRAN *for XENIX*	695	**546**
Pro FORTRAN *by Prospero*	390	**345**
RM/FORTRAN *by Ryan-McFarland*	595	**Call**
Scientific Subroutine Library *by Peerless*	175	**149**
Scientific Subroutine Package *by Alpha*	295	**269**
The Statistician *by Alpha Computer*	295	**269**
Strings & Things *by Alpha Computer*	70	**59**
OTHER LANGUAGES & UTILITIES		
Microsoft COBOL Compiler	700	**499**
Microsoft COBOL Compiler *for XENIX*	995	**795**
Microsoft COBOL Tools *with Source Debugger*	350	**259**
Microsoft COBOL Tools *for XENIX*	450	**333**
Microsoft Lisp *New Common Lisp*	250	**189**
Microsoft MuMath *Includes MuSimp*	300	**199**
Microsoft Pascal Compiler *Links with M'soft C*	300	**199**
Microsoft Pascal Compiler *for XENIX*	695	**546**
Pro Pascal *by Prospero, ISO Validated*	390	**345**
RM/COBOL *by Ryan-McFarland*	950	**675**
RM/COBOL 8X *ANSI 85 COBOL*	1250	**995**
Source Print *Aldebaran's diagrammer*	139	**109**

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NEW!

A Mighty Fortress Is Their FORTRAN

Picking over features of rival products is not necessary if FORTRAN is your need, still the citadel of scientific and engineering work. Ryan-McFarland has left the competition battering at the gates.

RM/FORTRAN™ is a complete implementation of FORTRAN-77 (ANSI X3.9-1978), the only PC FORTRAN certified by the General Services Administration at the highest test level. The reason: it's a big mainframe compiler moved to PCs, with the bonus that mainframe and mini applications can wander between environments.

Now, on your PC, you can develop large applications, with programs up to 640k (bigger using overlays), arrays over 64k, and using a long list of VS, VAX and FORTRAN-66 extensions you may have grown fond of — long symbolic names, "include", IRT bit functions — because R-M has left out nothing.

But what really sets RM/FORTRAN apart is optimization. The compiler reduces the number of instructions to the minimum which will actually execute, and even takes advantage of each processor's features to deliver lightning-fast object code. It runs 30%-40% faster than Microsoft 3.2, and could make your mainframe not worth the trouble.

Comes with an interactive symbolic debugger like that accompanying IBM VS FORTRAN, Plink86 subset, has a cross reference compile option, supports assembler and C subroutine calls, IEEE floating point, 8087 and 80287 chips.

"Compiler's documentation, ease of use, speed of execution, and debugger facilities place it first for recommendation" said the *Tech Journal* (10/85).

R-M has been writing FORTRAN compilers for IBM, DEC, etc. for 20 years. There is no greater expert.

Ask for:	List:	PC Brand:
I0300	$595	**Call**

RUN/C PRO

C Interpreter Links Binary Libraries

Run/C comes in an apprentice and pro version. The professional model dynamically loads and unloads multiple binary function libraries like C-Food Smorgasbord™ and Halo Graphics™ — potentially any library compiled with Lattice's large model. Inside this interpreter your C program can reach for functions in the best of commercial libraries.

This C interpreter behaves like PC BASIC meets WordStar®. Use fullscreen editing to create a program. RUN it. If it stumbles, LIST it, EDIT it, RUN it again, fix it again. Use familiar commands like LOAD, MERGE, SAVE, FILES, even TRON and TRACE.

Ideal for program development. Put up code at high speed, try out things devil-may care, let RUN/C find your malaprops. Blast away until tight little code segments are undyingly faithful.

Lots more features: system interrupts, a shell command to invoke any operating system command without leaving Run/C, debugging aids ingeniously installed as a Run/C function. Call for debugging conditionally from within your program, a specific function or a menu of aids including immediate mode, single-step tracing, changing of variable values.

Manual shows how to develop the interface to a commercial library, using the Lattice compiler (a must!). Link your own function archive the same way. (320k minimum; 512k recommended to fit libraries.) Ask for: S0950 List: $250 PCB: $185

PLINK86 PLUS

Cached Overlays Maximize Memory Use

Long the overlord of overlay linkers, Plink86 shoehorns large programs into small machines by swapping program segments in from disk to save memory. A 512k program could run in a 128k machine, for example. But Plink86 Plus is smarter still: if it finds itself in a larger machine, it moves program overlays into leftover memory. Overlays now swap at memory speed not disk speed. Can automatically restore a displaced overlay to which a subsequently called overlay must now return, and assign library modules to the root segment or overlay areas. Plink86-Plus: List: **$495.** Us: **$359**.

LATTICE C COMPILER

Major Upgrades to the Best Selling C Compiler

Lattice now embraces key UNIX™ enhancements which have entered the language since K&R: void functions returning no value, enumerated data types to assign stepped values to variables, data passing between structures by assignment.

The greatly expanded libraries (325 functions!) enable the file sharing and record locking provisions of DOS 3.1, provide a full complement of transcendentals, and a host of utilities to mimic the UNIX and XENIX™ environments.

Lattice 3.0 defaults to the ANSI proposed standard when you need strict adherence, but command line options restore leniency. And it adopts ANSI checking of external function arguments by data type to kill bug swarms when modules join up at link time.

Lattice now delivers smaller .EXE files, boasts very fast link times and a more efficient aliasing algorithm. New options generate code to use 80186 and 80286 features; 8087 of course sensed and utilized. Lattice has enjoyed pre-eminence so long that developers have created far more snap-on tools for Lattice C than any other compiler. William Hunt's *PC Tech Journal* review of 12 compilers awarded Lattice the only "very good" rating for add-on library availability.

Ask for:	List:	PC Brand:
S0100	$500	$299

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We ship anywhere. Phone or Telex your order. Credit cards: We need card number, expiry date, name and address of card. Or wire funds to PC BRAND, c/o Chemical Bank, 126 East 86th St., NY NY 10028, Account No: 034-016058. **We'll ship immediately** and confirm by Telex if you provide number.

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Convert Microsoft BASIC. Structured, Compilable.

Combines the familiarity of BASIC with the best features of C, Pascal, and Modula 2, yet BetterBASIC is 100% compatible with Microsoft's GW™ BASIC and IBM BASICA including graphics, sound, and assembly language calls. So load your old programs and RUN. SAVE and they are converted automatically to BetterBASIC!

It's big: Needs 192k; programs can go to the PC's full 640k. It's comfy: Behaves like M'soft BASIC at the interactive level, with a full-screen editor, direct statement execution, and always poised to RUN. It's fast: Each statement checked and compiled once, not every time encountered. Sieve runs *6 times faster* than with M'soft.

C-like structures house file records so goodbye to FIELD, MKI$, CVD, LSET, etc. Named "procedures" replace GOSUBs to linenumbers. Lots more features: built-in linker for compiled modules; trace; debugging breakpoints; cross-reference command; 32k strings; DOS and BIOS calls and interrupts; recursion. Run-time module stores object code for redistribution.

Ask for::		List:	Us:
S1200	BetterBASIC	$195	$165
S1201	Run-time Module	$250	$225
S1202	8087 Interface	$99	$85
S1205	Btrieve Interface	$99	$85

GSS GRAPHICS SYSTEM

ANSI CGI STANDARD! PRICES CUT!

Leave the Device Driving to GSS

GSS™ has reconfigured two components of its comprehensive graphics tools to conform with the ANSI Computer Graphics Interface (CGI) standard.

At the heart of the system is the Development Toolkit which contains all language interfaces and device drivers for keyboards, mice, joysticks, tablets, printers, plotters, cameras, and more. Drivers house management of vector graphics (plotters) and bitmaps used by raster input devices (scanners) to insulate the application program from concern for device idiosyncracy. No one else has implemented CGI that way. It means your programming remains generic; just switch drivers and the same program will drive a different device.

GSS Kernel™ conforms to level 2b of ANSI's Graphical Kernel System (GKS) and contains all its needed drivers and language bindings. Kernel has macro level tools to draw and color an object, store the sequential instructions, and recreate the object on its own, as well as segment it, transform it, etc. So powerful, a single command may represent several score lower level statements.

Plotting has the equivalent GKS tools for graph and chart generation and their captioning: hand it apples and oranges, say "pie", and it bakes the numbers into a digestible display for screen or plotters.

Kernel and Plotting have tools to convert images they create to ANSI Computer Graphics Metafiles (CGMs), a tokenized standard for storing every form of graphic image as data. The Metafile Interpreter reads the contents of a CGM and interprets it with full CGI capability for recreation on various devices.

Quality software? IBM thinks so. They sell the GSS series under their own label.

Unit royalties and annual fees have been instituted for redistribution. Needs 256k.

Ask for:		List:	PC Brand:
GS010	CGI Dvlpmt Toolkit	$495	$375
GS020	Kernel System	$495	$375
GS025	Kernel for IBM RT	$795	$645
GS030	Plotting System	$495	$375
GS040	Metafile Interpreter	$295	$235

BTRIEVE

ASK ABOUT XTRIEVE & RTRIEVE

Queen B-tree File Manager Abdicates Royalties

There's no longer a tithe to incorporate Btrieve™ in applications, a welcome proclamation if royalties would ruin your profit margins. Btrieve takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, forward and backward searching. It builds function call "commands" right into the language you use: interfaces to C, Pascal, BASIC, and COBOL, with sample programs in all four, come with each copy.

Btrieve has mainframe specifications! Its balanced-tree indexing scheme finds any key in a million in four or less accesses. Files may have up to 24 indexes; fixed record length to 4090 characters; indexes up to 255 characters; files of 4 billion bytes. Can even extend a file across two drives — even two hard disks!

Version 4.x speeds DOS interaction for large multiply-keyed files; enables variable length records of virtually any length; verifies accuracy (optionally) with read after write, useful in gritty environments; offers password and data encryption.

There's also Xtrieve, for Btrieve file inquiry and data manipulation, and Rtrieve for report writing. All three in versions for any network that supports the MS-DOS 3.1 file sharing function.

Ask for:		List:	PC Brand:
S0650		$250	$195
S0652	Network Version	$595	$465

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Licenses: Each price is for a license to use a product on a single computer and does not constitute *its ownership*. We will inquire for you about site licenses. Except as otherwise indicated or where "#" follows the Product Code, products may be used to create programs for distribution without royalty payments or additional licenses, provided said programs do not substantially replicate the products themselves.

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Returns: See box page one. Defective parts will be replaced. Please call for authorization to return a product for refund.

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Prices, terms, and specifications subject to change without notice.

IBM's new 2,400 bps PC Modems give you an easy choice:

Either

Stand-alone.
The IBM 5842
2,400 bps Modem.

Either way, you can't go wrong.

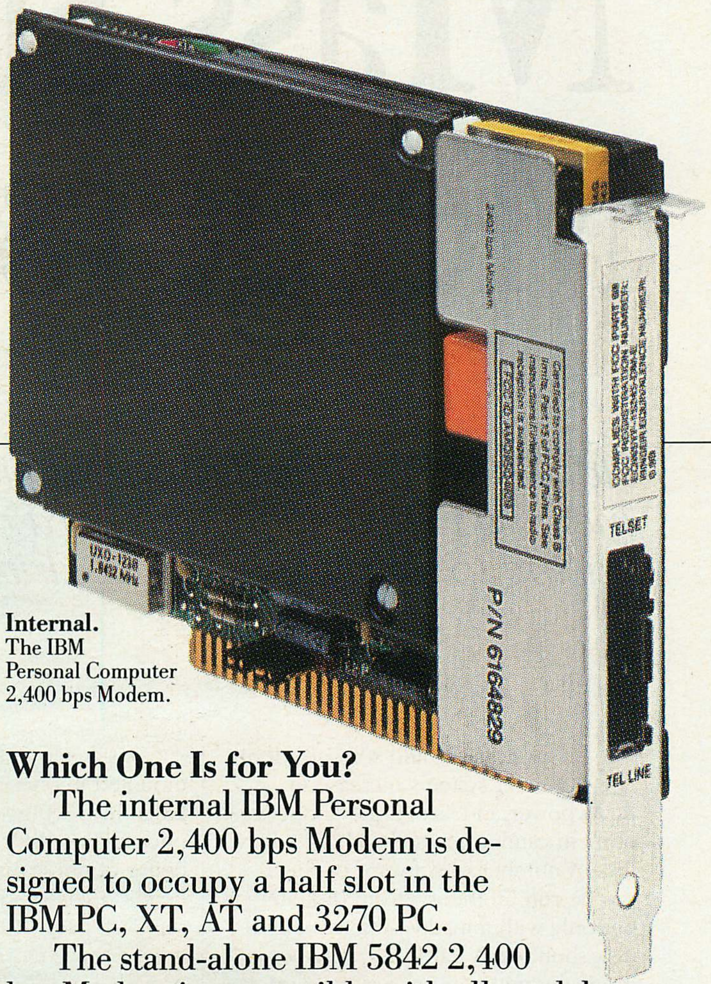
With IBM's new modems and a personal computer you can tap into information at a very impressive 2,400 bits per second (bps).

That translates into a binary file transfer speed of nearly 13 K characters per *minute*—or over six pages worth. Now *imagine* the impact that can have on your long distance telephone bill.

But these new modems aren't just fast, they're also versatile. They can both send and receive data asynchronously at speeds ranging from 2,400 bps down to 75 bps.

Both modems are compatible with the *popular* "AT" command set, as well as the *IBM* command set. And they have been tested for compatibility with leading PC communications software such as Crosstalk™ XVI, Microsoft® Access, Kermit, Smartcom® and Smartcom II®.

or



Internal.
The IBM Personal Computer 2,400 bps Modem.

The Automatic Modems

These modems feature Automatic Adaptive Equalization at 2,400 and 1,200 bps—which means they will continuously fine-tune themselves to compensate for changes and noises on the telephone line. The result is, you can receive data over a wider range of telephone line conditions.

Both modems also feature automatic or manual answering and dialing. They'll automatically switch to pulse dialing if tone dialing doesn't work. They have automatic redialing. And once a connection is made, automatic speed detection. They also have automatic detection of a voice or a failed call.

A Modem with a Memory of Its Own

The stand-alone IBM 5842 2,400 bps Modem offers some additional features. It can also send and receive data synchronously at speeds of 2,400 bps or 1,200 bps. You'll find extensive "Help" menus. A dial directory for 20 phone numbers. A log-on directory for five log-on sequences. A built-in pattern generator for self testing. Diagnostics implemented from the front panel as well as from the computer keyboard. And a complete array of LED Status Indicators to give you a quick visual check on what's happening.

Which One Is for You?

The internal IBM Personal Computer 2,400 bps Modem is designed to occupy a half slot in the IBM PC, XT, AT and 3270 PC.

The stand-alone IBM 5842 2,400 bps Modem is compatible with all models of IBM Personal Computers. And, in addition to the features mentioned above and its internal power supply, the significant difference is that a stand-alone modem can be moved from PC to PC more easily than an internal modem.

If you feel that 2,400 bps is more modem than you need, we also offer the stand-alone IBM 5841 1,200 bps Modem, and the internal IBM Personal Computer 1,200 bps Modem.

For the Authorized IBM PC Dealer nearest you—or for free literature on the IBM family of PC Modems—call 1 800 IBM-2468, Ext. 936/EM. Or you can contact your IBM marketing representative.

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CIRCLE NO. 172 ON READER SERVICE CARD

Mass-Storage Mergers

Hard disks mounted on cards give PC users the increased capabilities of a hard disk without having to sacrifice a diskette drive bay.

PETER G. AITKEN

As applications and software development systems increase in power and size, more and more of them cannot be used without a hard disk. A number of software packages can be run, in theory, from diskettes, but only with a maddening amount of disk shuffling. A hard disk, whether as original equipment or as an add-on, has become an almost essential part of any PC system intended for serious business or technical applications.

Some owners of dual-diskette PCs are hesitant to upgrade with a standard internal hard disk, even when the cost of the disk is not an obstacle. Recognizing this hesitation, several vendors have introduced *hard-disk cards*, which integrate a Winchester disk and controller on a single expansion board. These products overcome some of the drawbacks of a standard internal hard disk.

A standard hard disk must be mounted in one of the diskette drive bays; this requires either removal of one diskette drive or the added expense of purchasing one or two half-height diskette drives. Furthermore, standard internal hard disks almost always require more power than can be provided by the PC's original 63.5-watt power supply, necessitating a power supply replacement. Installing the hard disk and the replacement power supply may seem to be a forbidding task even to users who would not hesitate to install a memory expansion card.

These problems were first addressed by Plus Development Corporation's Hardcard, introduced 18 months ago; it combined controller circuitry and a low power 10MB hard disk on an expansion card. The 10MB Hardcard was selected as *PC Tech Journal*'s Prod-

PHOTOGRAPH • WALTER LARRIMORE/BLAKESLEE-LANE

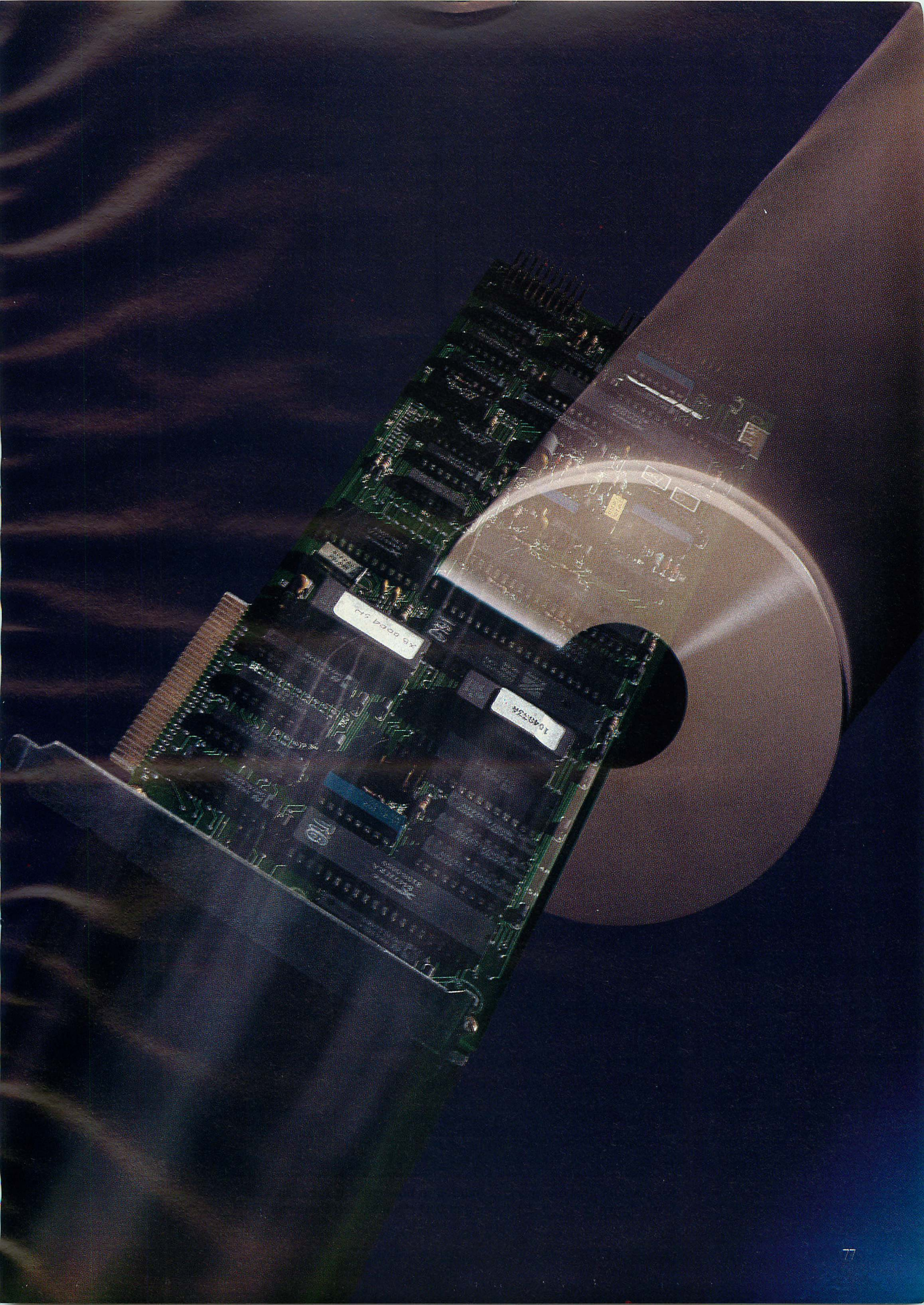
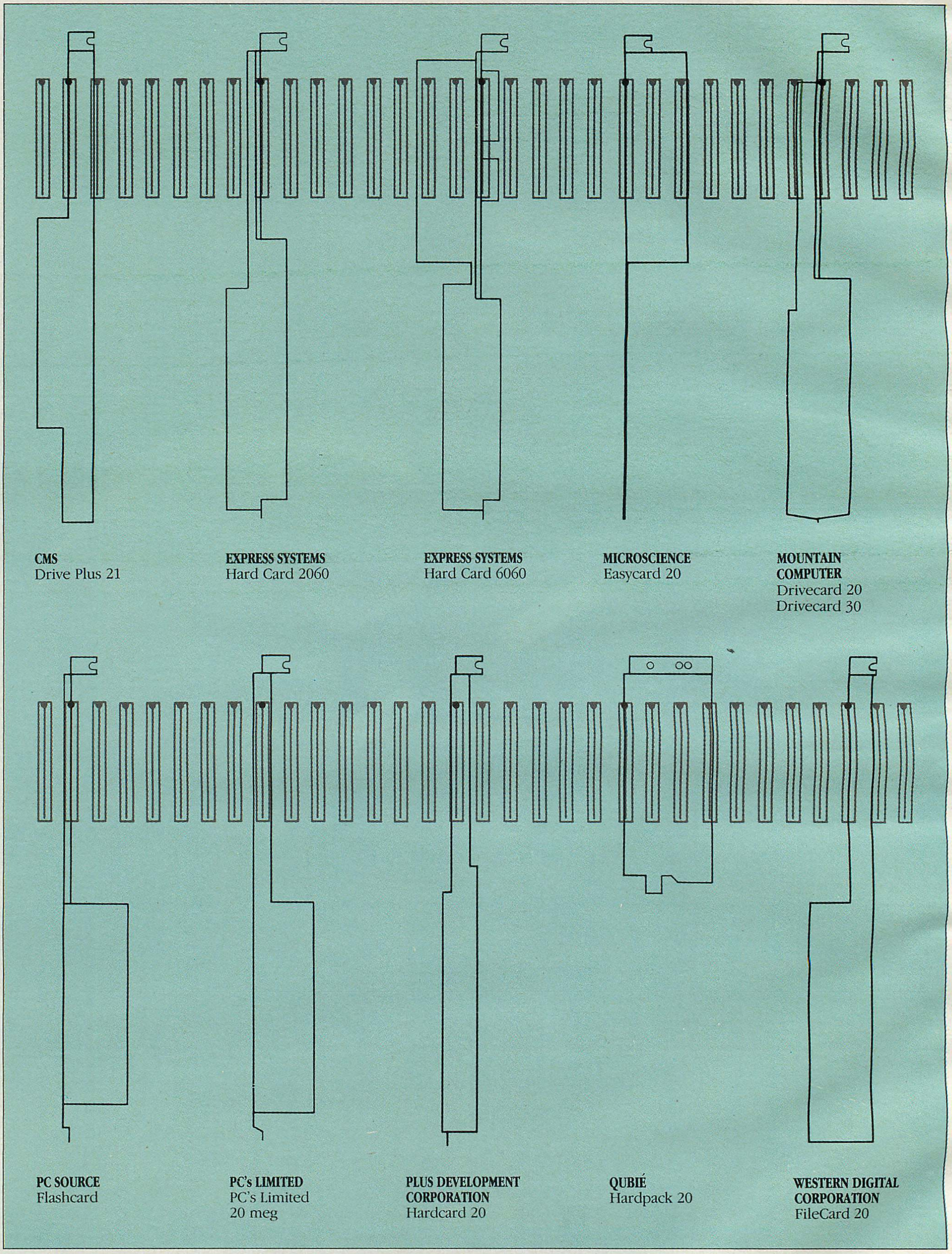
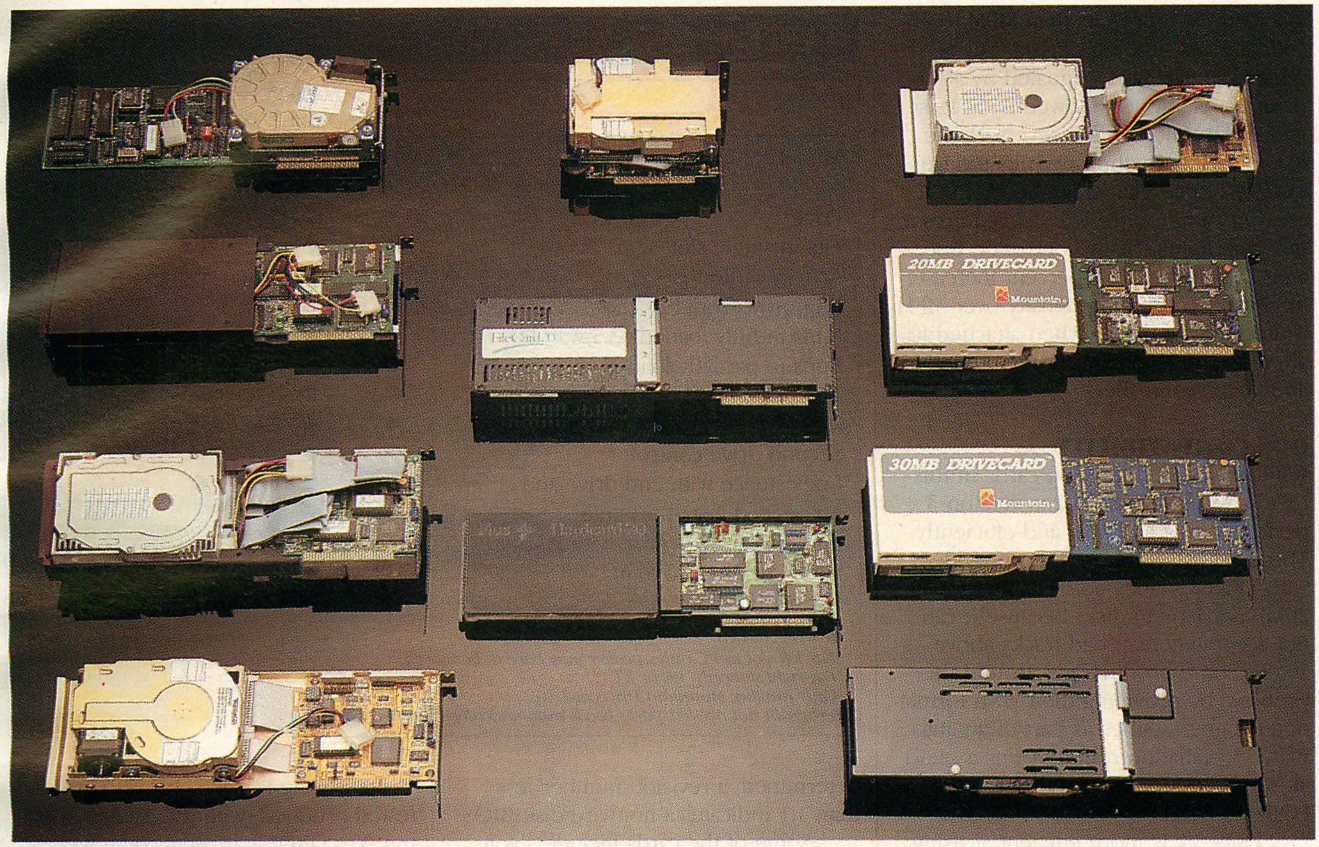


FIGURE 1: *Form Factors of Hard-disk Cards*



Careful study of the way a disk product uses bus space in addition to how much it uses can lead to a board mix that wastes few if any slot resources. The slots are shown at the PC/XT spacing of 0.8125 inch; each connector is 3.375 inches long.



PHOTOGRAPH • BLAKESLEE-LANE

These 11 cards offer several options for upgrading to a hard disk. They are (from top to bottom) left column: Microscience Easycard 20, Express Systems Hard Card 2060, Express Systems Hard Card 6060, and PC's Limited 20 Meg; middle column: Qubié Hardpack 20, Western Digital FileCard 20, and Plus Development Hardcard 20; right column: PC Source Flashcard, Mountain Computer Drivecard 20, Mountain Computer Drivecard 30, and CMS Drive Plus 21.

uct of the Month in February 1986 (p. 31) and was reviewed in the same issue ("Storage on a Card," Thomas V. Hoffman, p. 139).

Since then, hard-disk cards have been proliferating, with the most recent crop featuring 20MB (or more) of storage. This article examines eleven hard-disk card products: nine with 20MB of storage—CMS Drive Plus 20, Express Systems' Hard Card 2060, Microscience's Easycard, Mountain Computer's Drivecard 20, PC Source's Flashcard, PC's Limited 20 Meg, Plus Development's Hardcard 20, Qubié's Hardpack 20, and Western Digital's FileCard 20; one with 30MB—Mountain Computer's Drivecard 30; and one with an impressive 60MB—Express Systems' Hard Card 6060. The features of each card are summarized in table 1.

Because these cards occupy valuable space in the PC's slots, their size is an important consideration. Some of the cards require only one full slot, either by virtue of their thinness or because mounting them in an end slot allows their extra bulk to protrude beyond the card area where they do not block an adjacent slot. Others require 1½ slots allowing a half-length card to be mounted next to them. Only the Express Systems 60-MB unit with two separate drives on one card occupies two full slots. Physical configurations for all of the hard-disk cards are diagrammed in figure 1.

CODING METHODS

Hard disks operate by recording magnetic information on the surfaces of the spinning platters. Before any data are recorded, all of the magnetic particles in the platter coating are aligned the same way. During the write process, electric currents in the read-write head induce flux reversals, or changes in magnetic orientation, in the magnetic particles. During the read process, these flux reversals can induce minute electric currents in the read-write head. The design of the read-write head imposes limitations on the minimum and maximum spacing of flux reversals; if they are too far apart or too close together, they cannot be read reliably. In most systems, the presence of a flux reversal represents a binary 1 and the absence of a reversal represents a binary 0. Before being recorded, digital data must be encoded to prevent flux reversals from being spaced too far apart, as might happen in recording a long string of binary 0s.

An early method of encoding digital data for hard-disk storage was *frequency modulation* (FM). Because this coding method required one clock bit for every data bit, the effective data recording density was only 50 percent.

Modified frequency modulation (MFM) is now the most common coding method and is used in most of the products in this review. MFM does not record one clock bit for each data bit, but uses the incoming data stream to generate the clock signal in the controller. An extra flux reversal is inserted between consecutive 0s to prevent flux reversals from being spaced too far apart. Compared to FM, MFM adds many fewer extra bits to the data, allowing for a significantly higher effective recording density.

Run length limited (RLL) is a newer coding method used by some of the reviewed hard-disk cards. RLL translates the incoming data into a special digital code in which the number of 0s in sequence, the run length, is tightly controlled. In the most common RLL scheme, RLL 2,7, the number of 0s in sequence varies between 2 and 7. RLL

TABLE 1: *Hard-disk Card Features*

	CMS	EXPRESS SYSTEMS	EXPRESS SYSTEMS	MICRO-SCIENCE
Model	Drive Plus 21	Hard Card 2060	Hard Card 6060	Easy-card 20
Price	$895	$595	$1,095	$650
Fits in single slot	● [a]	● [a]	○	● [b]
Activity indicator	○	○	○	○
All power from bus	●	○	○	○
Runs in fully loaded 63.5-watt PC	●	○	○	●
Runs in partially loaded 63.5-watt PC	●	○	○	●
Automatic head lifting	○	●	●	○
Low-level format done at factory	●	●	●	●
Second drive control	○	●	○	●
Coexistence with 2nd drive and controller	○	●	●	○
Automated install program	○	○	○	○
Software allowing use with PC1 ROM BIOS	○	●	●	○
Head-parking program	○	●	●	●
Format program	○	●	●	●

● *=Yes* ○ *=No*
[a] *Far left slot in PC only; speaker may have to be moved.*
[b] *Far right slot only; PC or XT.*
[c] *Only another Mountain Drivecard 30.*
[d] *Program not needed; parks heads automatically.*

2,7 requires more bits than MFM to encode a given amount of data, but because each digital 1 (signaled by a flux reversal) is always followed by at least two 0s (absence of flux reversal), the RLL encoding method permits the frequency of the data stream to be increased significantly. RLL 2,7 requires a more complex, costly controller, but typically permits a 50-percent increase in effective recording density over MFM. A disk holding 20MB when attached to an MFM controller can hold 30MB with an RLL 2,7 controller.

DOS COMPATIBILITY

While all of the hard-disk cards in this review work with DOS 2.x, version 3.x performs more reliably and efficiently. The FORMAT.COM program provided with DOS 2.x does not reliably format 20MB (or larger) disks because it cannot accurately map bad tracks above 16MB. Some products get around this problem by providing their own formatting program, either as part of an automated installation routine or as a stand-alone program to be used instead of FORMAT.COM.

DOS 3.x is more efficient at using disk space; it uses a 2,048-byte cluster size rather than the 8,192-byte size used by DOS 2.x. Note that three of the cards in this review (the two Express Systems hard-disk cards and the PC Source Flashcard) come from the factory preformatted with 8,192-byte clusters. Even if DOS 3.x is installed on these cards, the card must be reformatted with the 3.x format program to get the benefit of the smaller cluster size.

Early versions of IBM PCs, Compaq Portables, and AT&T PC6300s may have versions of the ROM BIOS that do not recognize a hard disk. This prevents not only booting from the hard disk, but also any access to it at all. The following BASIC program checks the BIOS version of an IBM PC:

```
10 DEF SEG&HF000
20 FOR X&HFFF5 TO &HFFFC
30 PRINT CHR$(PEEK(X));
40 NEXT
```

A date is displayed; if it is earlier than 10/27/82, this is the nonhard-disk BIOS.

For a Compaq portable, this BASIC program should be run:

```
10 DEF SEG&HF000
20 PRINT CHR$(PEEK(&HFFE6));
```

If the letter *A* or *B* is displayed, the computer has the nonhard-disk BIOS.

For the AT&T computer, the bottom panel must be removed and the revision number on the ROM BIOS chip determined; a revision number less than 1.1 indicates a nonhard-disk BIOS.

Some of the cards include a software patch that allows an early BIOS computer to recognize a hard disk. The computer must be booted from a diskette and the software patch run, after which the hard disk can be accessed. These software patches work only with DOS 2.0 and 2.1; and they do not permit booting from the hard disk.

INSTALLATION PROCEDURES

For this review, each hard-disk card was installed in a PC with a 135-watt power supply and two adjacent empty slots in order to assure adequate power and space for each card. The manufacturers' instructions for physically installing the cards ranged from excellent to nonexistent. For those cards that get all of their power from the PC's bus, the installation procedure is no different from installing a memory or other expansion card. Some hard-disk cards contain disk drives that require a separate connection directly to the power supply. Because most PCs are not equipped with a spare power supply lead, a *Y* adapter is needed to allow one power supply lead to serve as two. Most of the disks that require a separate power supply connection provide a *Y* adapter for use if the power supply itself does not provide a spare lead.

Once the hard-disk card was installed in the computer, the manufacturer's formatting and software installation instructions were carried out exactly as written using PC-DOS 3.1. All of the tested products, with the exception of the PC's Limited 20 Meg, come with low-level formatting already done; some also have high-level formatting done. Some of the disks come with a more-or-less automated installation program, while others require use of DOS programs FDISK and FORMAT. In all cases, following the manufacturer's installation instructions resulted in a bootable, working disk.

Following the installation, the card's logical specifications were determined by using a utility program called INFO (from the article "Finding Disk Parameters", Glenn F. Roberts, May 1986, p. 112). This information, along with weight, power consumption, and other data, is summarized in table 2.

An important consideration when installing hard-disk cards is the cooling system. These cards generate a significant amount of heat, considerably more than other expansion cards. They must receive an adequate supply of cooling air. Adjacent cards must not touch each other, and cables should be routed to minimize their interference with air flow. For early PCs a minor, IBM-approved modification is recommended to increase the supply of air to the expansion cards. A row of ventilation holes extending across the entire width of the front of the computer (the system cover must be removed to see them) should be blocked to force more of the cooling air to pass over the expansion cards. A piece of plastic tape

MOUNTAIN COMPUTER	MOUNTAIN COMPUTER	PC SOURCE	PC's LIMITED	PLUS DEVELOPMENT	QUBIÉ	WESTERN DIGITAL
Drive-card 20	Drive-card 30	Flash-card	20 Meg	Hard-card 20	Hard-pack 20	File-Card 20
$995	$1,195	$429	$409	$895	$499	$895
● [a]	● [a]	○	○	●	● [b]	● [a]
○	○	○	○	●	○	○
●	●	○	○	●	○	●
○	●	○	●	●	●	○
●	●	○	●	●	●	○
●	●	●	○	●	○	○
●	●	●	○	●	●	●
●	● [c]	●	●	○	○	○
●	●	○	○	●	○	●
●	●	●	○	●	○	●
○	○	●	●	○	●	○
●	●	●	●	● [d]	●	●
●	●	○	○	●	●	○

Because their drive mechanisms are mounted at the bus ends of their cards, the Qubié Hardpack and Microscience Easycard may interfere with access to the CPU socket and may prevent the installation of some accelerator boards. The Easycard also obscures the 8087 socket when mounted in the far right slot.

1-inch wide and 12 inches long can be used to cover the portion of the vent that is under the diskette drives. On later PCs part of this vent has been covered by IBM with tape. The Mountain Drivecards come with a piece of tape and instructions for this modification.

Some users might want to add a hard-disk card as a second hard disk to supplement an existing internal or external drive. Others might install the hard-disk card first, then add a second drive. In either case, adding a second drive is not a straightforward procedure because of the complex manner in which DOS interacts with hard disks.

The boot routine in the computer's ROM has the ability to integrate into the system add-on cards (such as graphics or disk controllers) that have their own on-board ROM code. After the boot routine has established the default interrupt vectors, it looks through absolute addresses C8000H - F4000H examining the code (if any) present at 2KB intervals. A valid adapter card ROM is signaled by a 55H and AAH being present in bytes 0 and 1, respectively, of the first 2KB block of the ROM. After a checksum is performed to test the integrity of the ROM module, control is passed to byte 3 of the ROM code (byte 2 contains a length indicator giving the number of 512 byte blocks in the ROM). The ROM routine does what is necessary to attach the adapter card to the system, for example, establishing and intercepting interrupt vectors. Control is then passed back to the boot routine, which goes on to examine the next 2KB block for additional ROM-based adapters.

Once the hard-disk controller has been attached to the system, DOS accesses the controller via four of the 8088's I/O ports. In the PC and compatibles, memory address C8000H is reserved for the base address of the controller's ROM BIOS code, and I/O ports 320H-323H are reserved for communication with the controller. Base address CA000H and I/O ports 324H-327H are reserved for a second hard-disk controller. Because most controllers are capable of managing two hard disks, a two-disk system can have either both disks under the same controller, or each with its own controller. With two disk controllers in the system, the possibility of trouble exists: if the ROM BIOS initialization routines of the two controllers are incompatible, conflicts may arise in interrupt usage or some other aspects of the low-level system access, preventing one or both controllers from functioning properly.

All of the reviewed hard-disk cards come from the factory configured as the first controller (that is, at ROM BIOS base address C8000H and I/O ports 320H-323H); they can be changed, via jumpers on the controller, to be the second controller (at CA000H and 324H-327H). Thus, all of them have the potential to coexist with another hard disk and controller. Furthermore, the controllers on all of the reviewed cards, with the exception of the Hardcard 20, can manage a second hard-disk drive in addition to the drive on the card. This makes it possible, at least in theory, to remove the original controller and have the controller on the hard-disk card control not only its own drive but also the second drive.

Some of the manufacturers provide detailed instructions on configuration, cable connection, and formatting for a two-disk system, and even offer cable kits for connecting a second drive to their controller. Others provide no information at all, and two (Qubié and Western Digital) have even mounted their controller cards so that it is impossible, without disassembly, to reach the jumper pins and cable connections.

OTHER CONSIDERATIONS

During operation, the read/write heads of a hard disk are kept floating just above the platter surface by the air flow generated by the rotating platters. In some disks, when the power is turned off and the platters coast to a stop, the heads come to rest on the platter surface. This is usually a gentle process that poses no threat of damage. For an extra safety margin, some disks (such as the Plus Hardcard 20) have a mechanical mechanism, called *head lifting*, that lifts the heads away from the platter surface when power is removed.

Head lifting is distinct from *head parking*, which refers to moving the heads, usually under software control, over a section of the platter that is not used for recording data. Head parking is recommended when the disk is going to be moved and may be subjected to rough handling, which might cause the heads to impact the platter surface and damage the magnetic coating. Most hard-disk mechanisms are capable of head parking; however, not all vendors supply head parking software.

Another consideration when judging hard-disk cards is their lack of activity indicator lights. External and standard-mount internal hard disks usually have a small LED that lights up when the disk is being accessed. Because disks on a card are totally hidden from view, they can offer no such visual signal. Only one of the reviewed cards offers activity indicators, although the sound of disk access is loud enough on most of them to be heard over a quiet power supply. Software drivers for the Plus 20 Hardcard provide a visual indicator in the form of a small plus sign that appears in the upper right corner of the screen when the disk is being accessed in text mode; an auditory activity indicator produces a quiet clicking

TABLE 2: *Hard-disk Card Specifications*

	CMS	EXPRESS SYSTEMS	EXPRESS SYSTEMS	MICRO-SCIENCE
Model	Drive Plus 21	Hard Card 2060	Hard Card 6060	Easycard 20
Disk parameters (from INFO. EXE)				
Surfaces	4	4	4[a]	4
Tracks	614	614	604[a]	614
Sectors/track	17	17	26	17
Bytes/sector	512	512	512	512
Sectors/cluster	4	16	16	4
Total space (bytes)	21,377,024	21,377,024	32.161.792[a]	21,377,024
Data encoding method	MFM	MFM	RLL 2,7	MFM
Interleave factor	3	1	1	3
Power consumption (watts)	13	13	24	14.2
Warranty	1 year[b]	1 year	2 years	1 year
Shock (Gs)	N/A	N/A	N/A	N/A
Calculated MTBF (K hours)	N/A	14	14	N/A
Drive manufacturer	Tandon	LaPine	LaPine	Microscience
Controller manufacturer	WD	Omti	Omti	Microscience
Weight (pounds)	2.3	2.6	4.5	2.7

N/A Not available
N/S Not supplied by manufacturer

[a]For each of the two drives.
[b]Subject to change by retailer.
[c]Depending on the direction of shock.

sound through the computer's speaker during disk access. Both indicators can be turned on and off.

THE TEST SEQUENCE

Each card in this review was put through the same sequences of tests. Two hard-disk benchmark programs were used to assess the cards' performances. ATDISK (see "Out from the Shadow of IBM," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52) measured two types of disk performance, low-level hardware operations and normal systems operations. Track-to-track seek time, average random seek time, and effective data transfer rate, all low-level hardware operations, were timed by using BIOS calls.

Normal system operations, i.e., file input and output, were timed by using DOS function calls to write, read, and then delete ten 20KB files. Performance on this last test varies depending on where the test files are located on the disk, and on the number of I/O buffers. Therefore, before this test was performed, the drive was reformatted with the format C:/s command; also, no BUFFERS= or FILES= statements were included in the CONFIG.SYS file.

AUTOTEST, the second benchmark, was first described in the article "Fixed-disk Benchmarks" by William Hunt (November 1984, p.64). This program times two types of disk operations: (1) reading data from varying numbers of sequential disk sectors, an operation typical of loading large program or data files, and (2) reading data from random sectors at various head-travel distances (expressed as fractions of total disk width), an operation similar to updating single records in a database application. The results for both ATDISK and AUTODISK are shown in table 3.

The hard-disk backup program Fastback from Fifth Generation Systems, Inc. was installed on each hard-disk card, and its performance in backing up and restoring files was tested. Fastback worked perfectly on all of the cards. Its performance— that is, the time required to back up a given set of files— varied by only a few percentage points among all of the products tested. This indicated that Fastback's performance was limited by the diskette drive, and that speed differences among the hard-disk cards did not affect the results.

The tests included one to determine power consumption. One attraction of these hard-disk cards is that some of them will allow PC owners to add a hard disk without having to replace their original 63.5-watt power supply. Some hard-disk cards, such as the Hardcard Plus20, require so little power that one can be confident that they will function in a 63.5-watt PC with almost any combination of boards in the other slots. Others, such as the Express Systems 60MB twin, are so power-hungry that they require a 135- or 150-watt power supply even if most of the computer's other slots are empty.

To determine which of these disks can function in a 63.5-watt PC, tests were run in a typically loaded PC with the original IBM 63.5-watt power supply, two full-height diskette drives, a diskette controller card, an IBM Color Graphics Adapter, an AST Megaplus memory card with 256KB, one printer port, and one serial port. The tests also were run on a fully loaded PC containing all of the above plus either a full-length internal modem (Hayes 1200B) or half-length IBM asynchronous communications card, depending on the physical configuration of the card being tested. (Some of the hard-disk cards did not leave sufficient room in the system for a full-length modem.)

The test consisted of cold booting the disk and then, using a batch file, copying files between the hard disk and both diskette drives for 15 minutes. By keeping one or the other diskette drive motor running constantly, this routine would place as large a load (if not larger) on the power supply as would ever be encountered in normal use.

With one exception, the cards that failed this test did so as soon as the computer was switched on. The power supply shut itself off within one second of being turned on. The one exception was the Mountain Drivecard 20, which booted successfully but became erratic during the copying test, causing "General write failure" error messages in the fully loaded PC. In the partially loaded PC, however, this card performed without any problems.

The results of the power consumption test should be interpreted with

MOUNTAIN COMPUTER	MOUNTAIN COMPUTER	PC SOURCE	PC'S LIMITED	PLUS DEVELOPMENT	QUBIÉ	WESTERN DIGITAL
Drivecard 20	Drivecard 30	Flashcard	20 Meg	Hardcard 20	Hardpack 20	FileCard 20
4	4	4	4	4	4	4
614	939	611	611	614	611	611
17	17	17	17	17	17	17
512	512	512	512	512	512	512
4	4	16	4	4	4	4
21,377,024	32,692,224	21,272,576	21,272,576	21,377,024	21,272,576	21,272,576
MFM	RLL 2,7	MFM	MFM	RLL 2,7	MFM	MFM
3	3	3	3	3	6	3
13	13	14	13	8	14	14
1 year	1 year	1 year	1 year	1 year	1 year	1 year
5	10	6	N/A	10	10	7/3[c]
20	20	28	N/A	40	10	20
N/S	N/S	LaPine	Tandon	Plus	Tandon	Fuji
N/S	N/S	WD	WD	Plus	N/A	WD
2.3	2.3	2.5	2.4	2.1	4.0	2.5

The difference between a 20MB and 30MB disk system need not lie in the type of media or the number of surfaces. RLL encoding can allow a drive capable of storing only 20MB via MFM recording to contain 30MB without physical modification.

caution. Only the Hardcard Plus20 has low enough power consumption to operate in a 63.5-watt PC with essentially any combination of other boards. The other cards that passed this test all consume 13-14 watts, so that in a fully loaded PC they probably cause the power supply to operate at near maximum output. For memory, modem, or other cards requiring slightly more power than do the ones used in this test, the power supply may need to be upgraded (see the accompanying sidebar).

CARD SURVEY

CMS. The CMS Drive Plus consists of a Western Digital controller and a Tandon hard disk. It does not comes with any software; the DOS programs FDISK and FORMAT are needed to prepare the disk. Low-level formatting has been done at the factory.

The instruction manual is short and to the point, but it contains the necessary information to install and use the drive. One problem with the documentation is that it describes an earlier design of the Drive Plus that differs slightly from the evaluated unit. The earlier design required power from the power supply through a *Y*-cable, and obscured half of the slot to its right.

In contrast, the tested unit derives all of its power directly from the bus, and its shape is such that a full-length card can be mounted to its right, while no card can be mounted to its left. Thus, the Drive Plus occupies two full slots unless it is mounted in the far left slot of a PC (the speaker does not need to be moved), in which case it takes up only one full slot. In terms of function, the Drive Plus agrees with the manual.

CMS's warranty on the Drive Plus requires some explanation. CMS will honor the warranty for one year after the drive has been purchased by the dealer, but the dealer is expected to handle all of the warranty service. CMS does not wish to deal directly with end users for either sales or service. To some extent the warranty terms are determined by the dealer who sells the unit, who may honor the full year as allowed by CMS or may limit the warranty to less than a year to cover shelf time before the unit is sold.

Express Systems. Express Systems markets a full line of hard-disk cards; models 2060 and 6060 were the tested products for this review. Both models use the LaPine Titan 3532 hard disk and Omti controllers. The 2060 uses one drive and an MFM controller to provide 20MB of storage, while the 6060 uses two drives and an RLL 2,7 controller to provide 60MB.

For an additional $95, a software utility called Coalesce is available that will overcome the DOS limit of 32MB per volume and allow the 6060 to act as one 60MB volume. Coalesce is actually a private-label repackaging of Golden Bow Systems' VFeature Deluxe, which was reviewed in connection with other large disk systems that break the DOS 32MB barrier. ("Breaking the 32MB Barrier," Thomas V. Hoffman, May 1986, p.94.) Without Coalesce, the 6060 installs as two 30MB drives (C: and D:).

Both of the Express Systems products come from the factory with low- and high-level formatting; once the card is installed, the user needs only to invoke the SYS C: command to copy DOS to the disk drive. The factory formatting is for a 8,192-byte cluster, so that users of DOS 3.x may want to reformat the disk (FORMAT C:/S) to obtain the benefits of a smaller cluster size. Although most users will not need them, utility programs have been provided for low-level format, with possible interleave factors of 1:1, 2:1, and 5:1.

The OMTI controller used by the Express Systems disks can control two hard disks and can coexist with another controller. The manual states otherwise, but it was printed before a controller firmware update made such coexistence possible. Instructions for connecting an existing hard disk to the Express controller are provided in the instruction manual, and a telephone number for technical support is provided if help is needed. Cables for connecting the second disk are available from Express Systems for $35. If specified when ordering, the necessary jumper settings will be shipped with the card.

The Express Systems cards come with a program, HDINIT, that allows a PC1 to recognize the hard-disk card. They also provide an installation program that copies HDINIT from their distribution disk to the user's diskette and modifies the AUTOEXEC.BAT file to run

TABLE 3: *Benchmark Results*

	CMS	EXPRESS SYSTEMS	EXPRESS SYSTEMS	MICRO-SCIENCE	MOUNTAIN COMPUTER
MEASURED DATA[a]					
Model	Drive Plus 21	Hard Card 2060	Hard Card 6060	Easy-card 20	Drive-card 20
ATDISK					
Track-track seek time	16.8	15.2	15.1	17.0	15.0
Average seek time	102.9	71.7	70.2	126.1	70.7
Effective transfer rate (KB/sec)	11.86	9.8	6.41	11.76	11.76
DOS file I/O (sec)	14.1	14.3	15.7	15.0	14.2
AUTOTEST					
Sequential read					
1 sector	19	19	16	19	19
8 sectors	49	38	33	44	47
16 sectors	82	63	49	74	77
24 sectors	115	91	66	102	110
Random 1-sector read					
0.10 width	76	67	59	91	60
0.33 width	106	85	85	136	88
0.50 width	137	100	99	170	110
0.90 width	190	135	100	231	143
Random 8-sector read					
0.10 width	104	88	80	115	88
0.33 width	137	107	83	162	118
0.50 width	169	124	118	195	135
0.90 width	223	154	118	253	179
PERCENTAGE OF AVERAGE PERFORMANCE[b]					
ATDISK					
Track-track seek time	106	95	95	107	94
Average seek time	123	85	84	150	84
Effective transfer rate (KB/sec)	108	89	58	109	107
DOS file I/O (sec)	94	95	104	100	94
AUTOTEST					
Sequential read					
1 sector	101	101	85	101	101
8 sectors	101	79	68	91	97
16 sectors	108	83	65	98	102
24 sectors	100	79	57	89	96
Random 1-sector read					
0.10 width	110	97	85	131	87
0.33 width	109	87	87	140	90
0.50 width	113	83	82	141	91
0.90 width	122	86	64	148	92
Random 8-sector read					
0.10 width	106	90	82	118	90
0.33 width	109	85	66	129	94
0.50 width	112	82	78	129	90
0.90 width	119	82	63	135	96
Average, random tasks	113	89	83	131	90
Average, sequential tasks	102	89	75	99	100
Overall	107.56	88.70	78.86	115.28	95.01

[a] *Times measured in milliseconds, unless otherwise stated.*
[b] *Lower percentage equals a better performance.*

HDINIT upon booting. This installation program is rendered useless because HDINIT causes the computer to reboot, and therefore, running it from an AUTOEXEC file will result in an endless cycle of reboots. The correct use of HDINIT.COM is simply copy it to the boot diskette and run it from the keyboard after booting.

Microscience. While similar in operation to the other 20MB units, the Easycard has a different physical configuration. It is a full-length card, but unlike the other tested units, it has the disk drive mounted at the bus end of the card (toward the rear of the computer). By installing the Easycard in the rightmost position so that the drive overhangs the CPU socket, it takes up only one full slot. If installed in any other slot, the Easycard requires two full slots. Accelerator boards using ribbon-cable access to the CPU socket *cannot* be installed with the Easycard in the right slot. In contrast to Qubié Hardpack 20, the Easycard does not interfere with access to the coprocessor socket.

The Easycard's disk and controller are manufactured by Microscience. The instruction manual is short and to the point and includes instructions for connecting the Easycard controller to a second hard disk. The brief instructions might pose problems for users who are unfamiliar with computers. Information on the utility programs that come with the card is not in the manual, but in an ASCII file on the utility disk.

Mountain Computer. The Drivecard 20 and Drivecard 30 look very similar and use disk drives that are, at least externally, identical. The 20MB model uses an MFM controller and the 30MB model uses an RLL 2,7 controller. The disks and controllers do not have a manufacturer's name on them (they are labeled, "Assembled by Mountain"), and a Mountain spokesperson said that this is "proprietary information."

The Drivecards can coexist with another hard disk/controller combination, using the Drivecard as the second hard disk and the original hard disk as the boot disk. The Drivecard controllers also can manage a second disk. Mountain recommends that only another Mountain 30MB drive be used as a second drive with the 30MB Drivecard controller. The 20MB controller can manage the following second drives: standard XT drive; Seagate ST412, ST225, and ST4051; NEC D3126 and D5146. Cables for connecting a second drive are available from Mountain.

PC Source. The Flashcard consists of a LaPine Titan 3532 disk and a Western Digital controller. According to the instruction manual, it comes with high-level formatting done for DOS 3.1. As with the Express Systems disks, its cluster size as received is 8,192 bytes, suggesting that it is actually formatted for DOS 2.x. Either DOS 2.x or 3.x can be installed and used, but the disk must be reformatted to obtain the smaller cluster size possible with version 3.x.

MOUNTAIN COMPUTER	PC SOURCE	PC's LIMITED	PLUS DEVELOPMENT	QUBIÉ	WESTERN DIGITAL	OVERALL AVERAGE
Drive-card 30	Flash-card	20 Meg	Hard-card 20	Hard-pack 20	File-Card 20	
13.5	15.3	16.8	8.3	16.8	25.3	15.91
70.0	81.6	93.8	44.1	97.9	94.1	83.91
9.8	11.76	11.88	11.76	22.52	11.92	11.93
13.6	14.4	14.2	17.7	16.7	15.9	15.07
19	19	19	19	19	19	18.7
41	44	49	47	91	49	48.4
63	77	82	77	107	82	75.7
88	110	118	110	242	115	115.2
59	76	77	44	80	73	69.3
92	93	107	60	109	110	97.4
110	118	139	71	140	136	120.9
110	159	192	85	194	179	156.2
71	102	104	71	151	102	98.0
104	126	137	88	181	137	125.5
132	143	168	99	214	162	150.8
132	184	223	113	266	209	195.8
85	96	106	52	106	159	
83	97	112	53	117	112	
89	107	108	107	205	109	
90	96	94	117	111	105	
101	101	101	101	101	101	
85	91	101	97	188	101	
83	102	108	102	141	108	
76	96	102	96	210	100	
85	110	111	64	115	105	
94	96	110	62	112	113	
91	98	115	59	116	112	
70	102	123	54	124	115	
73	104	106	73	154	104	
83	100	109	70	144	109	
88	95	111	66	142	107	
71	99	119	61	142	112	
86	99	111	58	121	123	
88	99	102	106	159	105	
85.56	98.96	106.61	81.76	140.18	113.78	

The three fastest drives in this evaluation all use RLL encoding, suggesting that the space efficiencies inherent in RLL create time efficiencies as well.

PC's Limited. The PC's Limited 20 Meg unit consists of a Tandon disk and a Western Digital controller. Once installed and formatted it performs well, but the installation instructions are inadequate. The instruction manual is largely inappropriate, because it is for a standard-mount internal hard disk and does not mention installing a hard-disk card. When asked, the technical support people at PC's Limited said that a note should have been included telling the users to ignore the installation instructions, because it is assumed they will know how to install the hard-disk card in their computers.

The PC's Limited disk is the only one of those tested that did not come with low-level formatting. The low-level formatting software is contained in the ROM on the controller card and must be run before the drive can be formatted under DOS and used. PC's Limited instructs the user to execute the formatter by loading DOS DEBUG and transferring control to the formatter's address in ROM using the **G** command. The formatting process is not difficult, and only involves entering the interleave factor and indicating whether the drive to be formatted is the first or second attached to the controller. Nontechnical users may find this process somewhat forbidding. A short DOS program to execute the low-level formatter would be better than requiring DEBUG for what amounts to a JUMP instruction. PC's Limited intends to supply such a program in a future release.

PC's Limited card requires a separate connection to the power supply (as do several of the others), but does not automatically include a *Y* connector for use in cases where the power supply does not have an extra lead. The *Y* connector is available separately for $7.50.

Plus Development. The Hardcard 20 stands out as being by far the thinnest and the least power-hungry. Plus Development designed a hard-disk card especially for compactness and low power consumption, rather than using a standard off-the-shelf disk as all the other products in this review do. Only one inch thick at its widest point, the Hardcard fits in any single slot between two full-length cards, anywhere in a PC or XT. Its power consumption is only eight watts, at least five watts less than any other disk tested.

The Hardcard 10 has a reputation for excellent reliability, and published mean time between failures (MTBF) figures for the Hardcard 20 have increased to 40,000 hours over 25,000 for the Hardcard 10. This is in many cases twice the MTBF figure for other hard-disk card products. The Hardcard 20 is also 15 percent faster than the Hardcard 10 overall, and leads most of the other hard-disk cards in almost every performance measurement for effective data transfer rate from disk.

The Hardcard comes with a menu program called Hardcard Directory, which allows users to select and run ap-

THE SEARCH FOR POWER

TABLE: *IBM 130-watt Power Supply DC Specifications*

VOLTAGE DC Nominal	CURRENT (amps) Maximum	REGULATION +%	REGULATION −%
+5.0	15.0	5	4
−5.0	0.3	10	8
+12.0	4.2	5	4
−12.0	0.25	10	9

The power supply also provides a 3.6-amp switched outlet at the input line voltage, which will support virtually all PC-oriented displays.

By and large, the 130-watt power supply in the PC/XT will operate with any combination of expansion cards on the I/O channel, including all of the hard-disk cards reviewed here. The 63.5-watt supply present in the PC, however, was not designed for hard disks and will not support the typical complement of add-on cards along with a hard-disk card without overloading. Under overload conditions, a well-designed power supply does not overheat, nor does it vary its output voltages beyond specified tolerances. It simply shuts down, as was the case with several of the tested cards.

IBM's 130-watt power supply (identical to the supply in the XT) may be purchased from IBM dealerships for $325. The supply is both UL approved and certified to comply with FCC Part 15 regulations. Its specifications are summarized in the accompanying table.

A host of compatible power supplies, some costing less than $100, have become available in recent years as the cost of add-on hard disks has plummeted. Most of these are imported and are identical to the PC and XT power supplies in physical dimensions. All of them quote electrical specifications identical to—or better than—IBM's. Some of the points to consider in shopping for power supplies are these:

Power output. While most upgrade power supplies provide either 135 or 150 watts, at least two vendors, Eltech and West Coast Peripherals, are offering a 180-watt supply, and May Corporation offers a 200-watt supply for the XT. (The power supply in the PC/AT, by comparison, is 192 watts.)

Noise level. No specification exists for power supply noise level, so evaluating supplies before purchase is difficult. Noise level increases with power, so even IBM's 130-watt supply will be noisier than the original 63.5 watt supply in the PC. In general, however, the imported power supplies are noticeably noisier than IBM's. One exception is the Silencer from PC Cooling Systems, a 155-watt supply that is far quieter than IBM's original 63.5-watt PC supply. It has been measured at 36 dB at one meter, compared to 44 dB for the PC/XT, 84 percent quieter.

UL and FCC approval. UL approval is a general indicator that a product presents no gross safety hazards. FCC approval under Part 15's electromagnetic interference (EMI) regulations indicates that a supply will not add significantly to the PC's EMI output. Not all power supplies carry UL and/or FCC approval; those that do are indicated in the list of vendors below.

Connector pin type. Even though some of the imported power supplies are identical in size to the PC and XT supplies, they cannot be installed in either machine because the motherboard power connectors are not compatible. While IBM motherboards use a rectangular pin .095 inch by .036 inch, the incompatible supplies are designed to mate with a .045-inch square pin used on many compatible motherboards.

Warranty. Warranty periods and terms on power supplies vary widely.

It is always a good idea to inquire about "restocking" fees when ordering goods through the mail. If a power supply is not compatible with a particular machine and yet has not failed, the vendor may deduct a penalty fee from the purchase price before issuing a refund.

—Jeff Duntemann

135-watt supplies, UL/FCC $83
Club AT Inc.
46707 Fremont Blvd.
Fremont, CA 94539
415/490-2201
CIRCLE 349 ON READER SERVICE CARD

180-watt supplies, $63
Eltech Research, Inc.
2380 Qume Drive, Suite C
San Jose, CA 95131
408/943-1764
CIRCLE 350 ON READER SERVICE CARD

150-watt supplies, UL/FCC $95
Floppy Disk Services
39 Everett Drive, Bldg. D
Lawrenceville, NJ 08648
609/799-4440
CIRCLE 351 ON READER SERVICE CARD

135-watt supplies, $69.95
150 watt supplies, $79.95
JDR Microdevices
110 Knowles Drive
Los Gatos, CA 95030
408/866-6200
CIRCLE 352 ON READER SERVICE CARD

200-watt supplies, $89
May Corporation
8210 Katella Ave.
Stanton, CA 90680
714/897-2037
CIRCLE 353 ON READER SERVICE CARD

155-watt Silencer, $165
PC Cooling Systems
31501 Via Ararat Drive
Bonsall, CA 92003
CIRCLE 363 ON READER SERVICE CARD

150-watt supplies, FCC $69
PC Source
12303-G Technology
Austin, TX 78727
512/331-6700
CIRCLE 354 ON READER SERVICE CARD

130-watt supplies, FCC $99
PC's Limited
1611 Headway Circle, Building 3
Austin, TX 78754
512/339-6962
CIRCLE 355 ON READER SERVICE CARD

180 watt supplies, $70
West Coast Peripherals
1855 O'Toole Avenue
San Jose, CA 95131
408/435-5467
CIRCLE 356 ON READER SERVICE CARD

plication programs from a menu rather than by entering DOS commands. The operation of this menu software is very similar to the Automenu shareware program available on many bulletin boards. The instruction manual for the Hardcard 20 is excellent.

Qubié. The Hardpack 20's physical configuration is unique among the cards tested. Rather than mounting the disk and controller end-to-end, the Hardpack mounts them side-to-side, resulting in a package that is short and wide. If it is mounted in the PC's short slot (the one closest to the power supply), it extends over the CPU area and takes up only one slot. The extremely tight fit requires diskette drive A: to be slid forward as far as possible so that the Hardpack can be installed.

The drive mechanism protrudes far enough to the right of the bus to completely obscure the CPU socket and about half of the coprocessor socket. Aside from obvious difficulties in installing a coprocessor, the Hardpack also makes it impossible to install an accelerator board that requires ribbon-cable access to the CPU socket. In this it is similar to the Microscience Easycard.

The Hardpack consists of a Tandon disk and a Qubié controller. In addition to several hard-disk utilities, the Hardpack comes with Bourbaki's 1Dir (visual shell) and ZyLAB's ZyINDEX (file search/index). The version of ZyINDEX included is limited to approximately 100 files, and an order blank is included giving one-third off the price of the full-powered version of ZyINDEX.

The instruction manual for the Hardpack is reasonably clear and complete, but the photographs of the installation steps are so murky as to be useless. The manual consists of a collection of loose IBM binder-size pages; the pages are not prepunched for a binder.

Western Digital. The FileCard 20 uses a hard disk made by the Fuji Electrical Co. and, of course, a Western Digital controller. Unlike the Western Digital 10MB FileCard, the FileCard 20 has no provision for piggyback memory or other add-ons. It comes with Executive Systems' XTREE disk management software and a clear and complete instruction manual that is punched for insertion into an IBM-size binder.

ATTRACTIVE ALTERNATIVES

Any of these cards provides a functional hard-disk system with the benefits of increased speed and storage capacity. If two slots are available with a hefty power supply and substantial storage needs, the Express Systems 6060, at $1,095, is an attractive alternative to more expensive high-capacity hard disks. This unit may also appeal to those who want to use one of its 30MB disks as high-speed backup for the other.

Among the smaller capacity models, no clear winners or losers stand out. The benchmark results show that overall performance differences between these hard-disk cards are relatively insignificant. The results also show that no single benchmark measure can give a true picture of a card's overall performance. For example, of the 20MB hard-disk cards, the one with the fastest random access time (Hardcard Plus20) had the slowest performance on the DOS files test, while the hard-disk card with the slowest random access time (CMS) had the fastest DOS files test.

Close inspection of the benchmark tables reveals that the variation in performance on the DOS file copy benchmark is fairly small across all products tested. However, this test was conducted on newly formatted disks with essentially no file fragmentation. Once a disk has been in use for some time and fragmentation has increased to normal levels, the performance of disks that have very fast random seek and random read times, such as the Plus Hardcard, can be expected to improve markedly.

Space and power considerations are more likely to be deciding factors. If only one slot is available and the original power supply is to be used, the CMS Drive Plus, the Hardcard Plus20, the Mountain 30MB Drivecard, and the Qubié Hardpack are the only choices. The Plus20 and Mountain 30 are a bit faster than the Qubié, but they are also significantly more expensive.

If 1½ slots and a 63.5-watt power supply are available, the PC's Limited unit deserves consideration. It is a no-frills unit that performs well at a very attractive price.

For only one slot and an upgraded power supply, the Express Systems 2060, Mountain Drivecard 20, and Western Digital Filecard are available choices. Finally, 1½ slots and a power supply upgrade make the PC Source Flashcard a possibility.

Peter G. Aitken, Ph.D., is an assistant professor in the physiology department at the Duke University Medical Center in Durham, North Carolina, where he uses IBM PCs extensively in his research. As a freelance consultant and programmer, he has written and marketed a package of laboratory software.

Drive Plus 21: $895
CMS
401 W. Dyer Road
Santa Anna, CA 92707
714/549-9111
CIRCLE 301 ON READER SERVICE CARD

Hard Card 2060: $595
Hard Card 6060: $1,095
Express Systems
1254-1/2 Remington Drive
Schaumburg, IL 60196
312/882-7733
CIRCLE 302 ON READER SERVICE CARD

Easycard 20: $650
Microscience International
575 E. Middlefield Road
Mountain View, CA 94043
415/961-2212
CIRCLE 303 ON READER SERVICE CARD

Drivecard 20: $995; 30: $1,195
Mountain Computer Inc.
360 El Pueblo Road
Scotts Valley, CA 95066
408/438-6650; 800/458-0300
800/821-6066, California only
CIRCLE 304 ON READER SERVICE CARD

Flashcard: $429
PC Source
12303-G Technology
Austin, TX 78727
512/331-6700
CIRCLE 305 ON READER SERVICE CARD

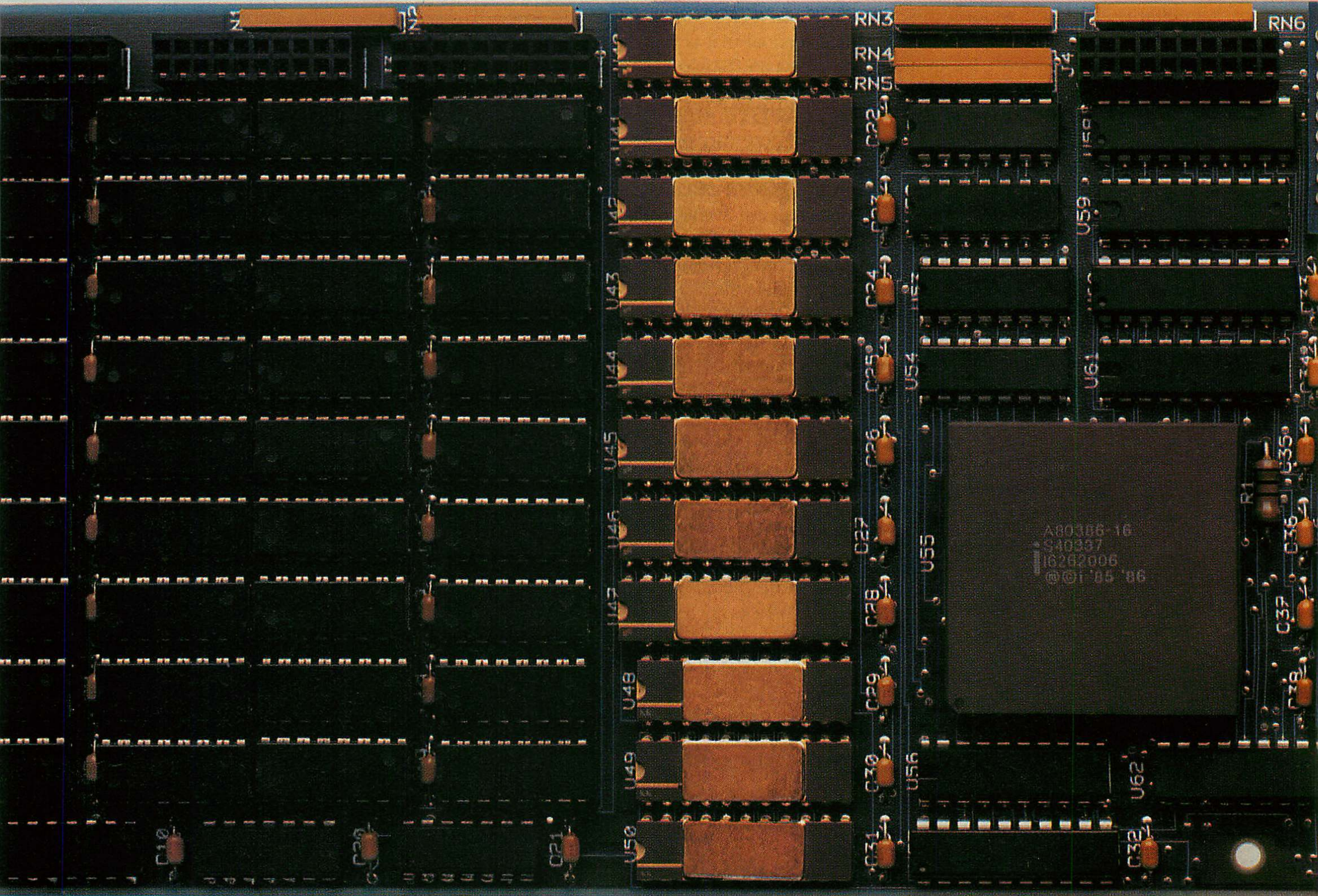
PC's Limited 20 Meg: $409
PC's Limited
1611 Headway Circle, Bldg. 3
Austin, TX 78754
512/339-6962
CIRCLE 306 ON READER SERVICE CARD

Hardcard 20: $895
Plus Development Corporation
1778 McCarthy Blvd.
Milpitas, CA 95035
408/434-6900
CIRCLE 307 ON READER SERVICE CARD

Hardpack 20: $419
Qubié
507 Calle San Pablo
Camarillo, CA 93010
805/987-9741
800/821-4479
CIRCLE 308 ON READER SERVICE CARD

FileCard 20: $895
Western Digital Corporation
2445 McCabe Way
Irvine, CA 92714
714/863-0102; 800/847-6181
CIRCLE 309 ON READER SERVICE CARD

How to 386



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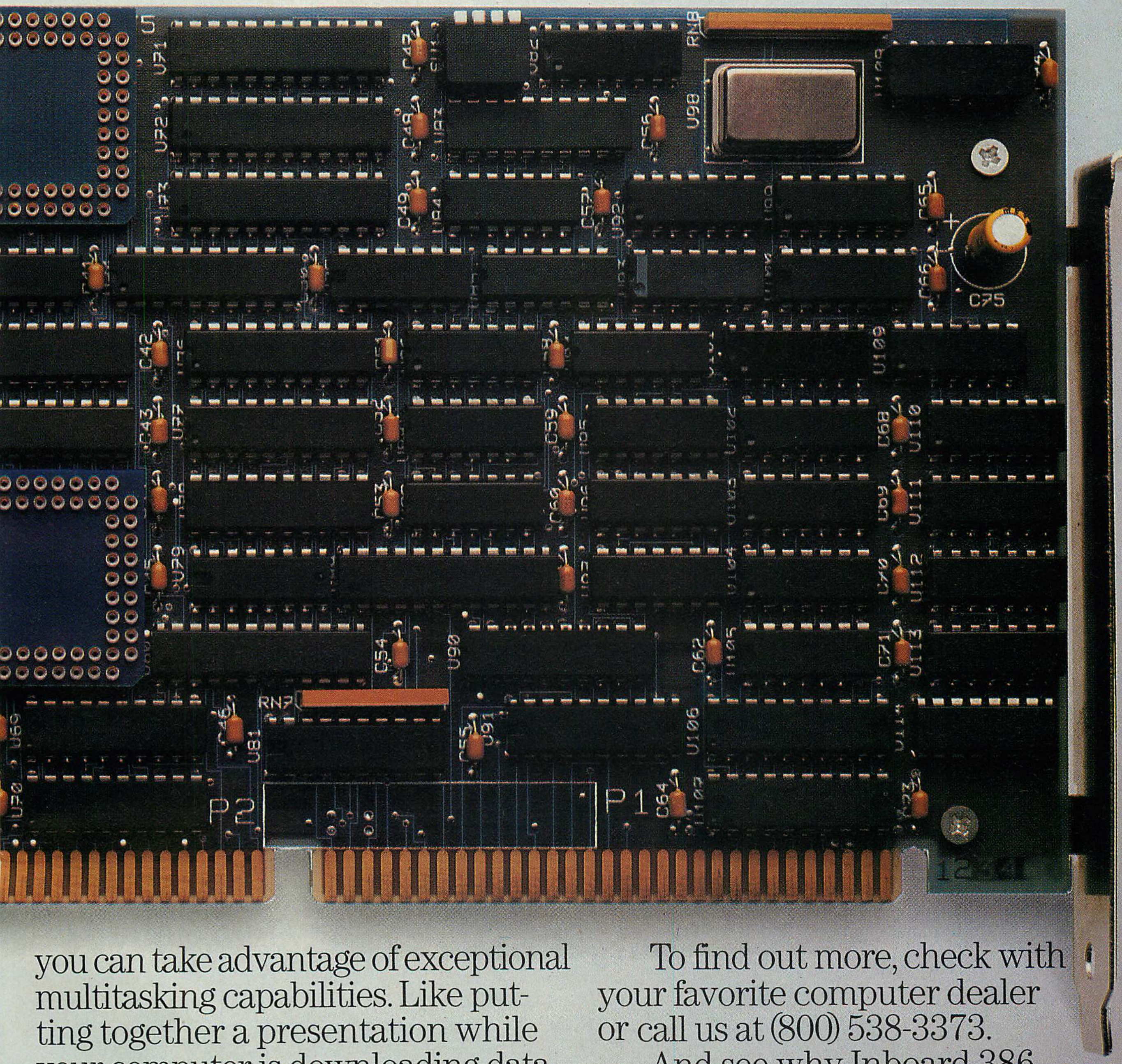

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OUT FROM THE SHADOW OF IBM:

TeleCAT-286

TeleVideo's AT compatible offers a few extras by combining a high-resolution color/graphics adapter and high-quality monochrome monitor, but it suffers from subtle incompatibilities.

STEVEN ARMBRUST and TED FORGERON

The TeleCAT-286 is the latest venture of TeleVideo Systems, Inc. into the personal computer market. With the chunky, boxy appearance that characterizes TeleVideo products, the TeleCAT-286 packs the power of an 8-MHz PC/AT into a small and affordable package. Subtle compatibility problems stand between this machine and a high recommendation, however.

The computer tested in this article contained 512KB of memory, a 20MB hard disk, a 1.2MB diskette drive, TeleVideo's high-resolution color graphics board, and a TeleVideo monochrome monitor. The system board came equipped with a serial and a parallel port as standard equipment. The accompanying sidebar lists the features available with the TeleCAT-286.

With custom chips shrinking the size of AT motherboards, small-footprint machines are becoming more common. These smaller machines are often limited in the number of drives they can hold. The TeleCAT-286 provides a balance between physical dimensions and storage capacity. The system unit measures 16.5 inches by 16 inches by 6.25 inches, 28 percent smaller than the AT. Photo 1 compares the footprint of the TeleCAT-286 with the AT's.

Like other machines with smaller system units, the TeleCAT-286 cannot hold as many drives as the AT, which has two storage bays that can handle two half-height diskette drives and two full-height hard disks. The TeleCAT-286 has a single storage bay in which two half-height drives can reside. The half-height 20MB hard disk is mounted on its side next to the storage bay; the 1.2MB diskette drive is mounted in the top of the bay, leaving the bottom available for expansion. The empty slot can be used to house either a diskette drive or a hard disk; data cables are provided for both, and a power connector is conveniently placed for easy installation. Photo 2 shows the inside configuration of the system unit.

PHOTOGRAPH • MARC DAVID COHEN


TeleVideo
TeleVideo

PHOTO 1: *System Unit Footprint*

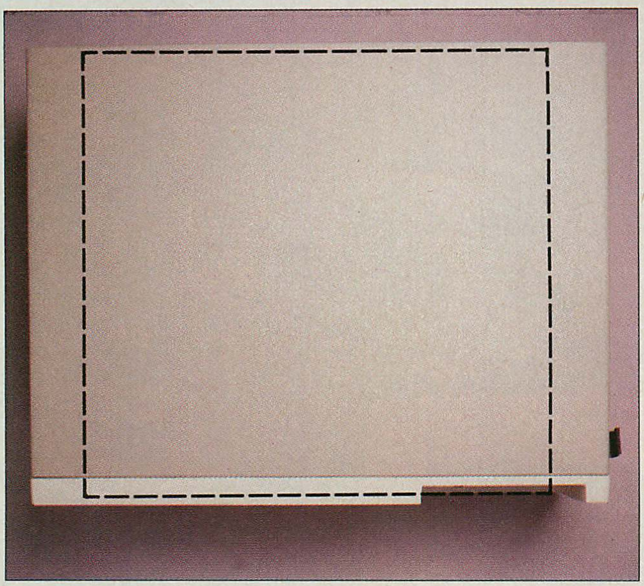

PHOTO 2: *Inside the System Unit*

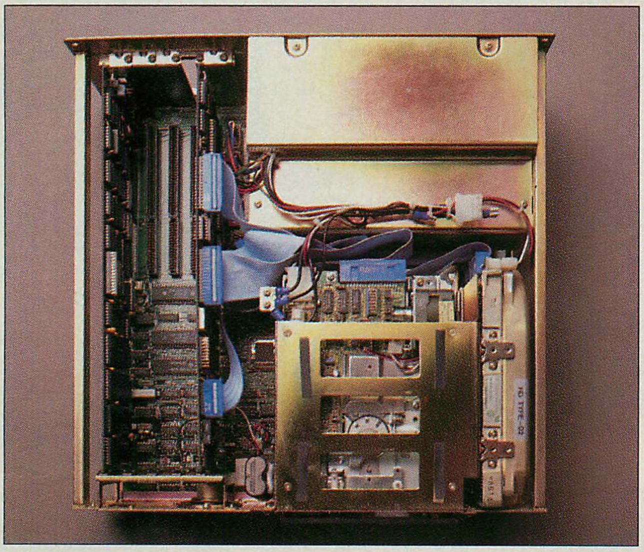

PHOTO 3: *Keyboard Comparison*

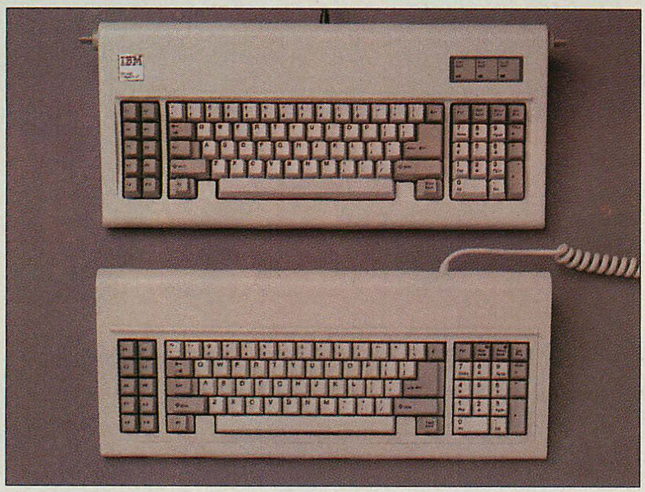

PHOTO 4: *Rear of the System Unit*

PHOTO 5: *TeleCAT-286 Styling*

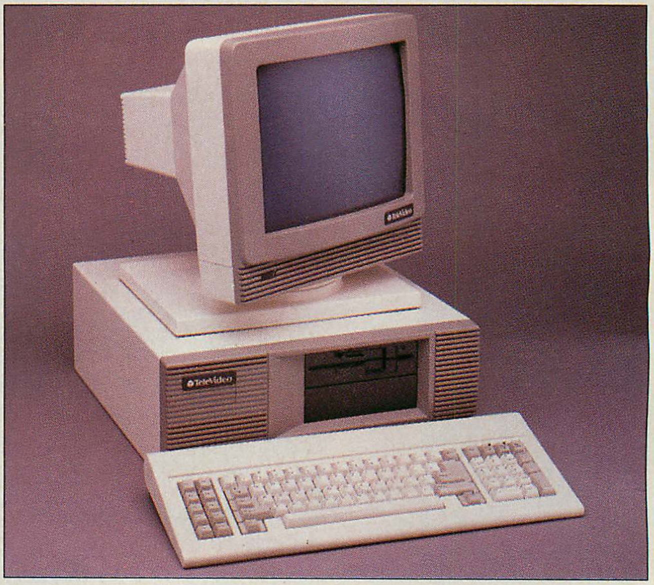

PHOTO 6: *Slide-rail Mechanism*

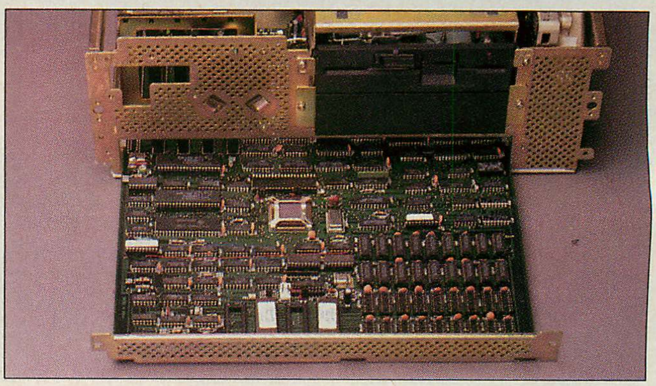

Photo 1: The TeleCAT-286's system unit is considerably smaller than the PC/AT as indicated by the dotted lines.

Photo 2: Inside the system unit, the hard disk is mounted on its side to the right of the diskette drive.

Photo 3: The keyboard is similar in layout to the AT keyboard. The status lights are conveniently placed on the keys.

Photo 4: The rear of the system unit shows the built-in serial and parallel ports, as well as the processor speed switch.

Photo 5: The TeleCAT-286 has the styling that is distinctly TeleVideo. It features a TeleVideo monochrome monitor.

Photo 6: When disconnected, the system board slides out the front of the unit for easy access to the interior.

The unit tested contained a 20MB Seagate drive, the average access time of which is rated by TeleVideo at 85 milliseconds (ms). *PC Tech Journal* tests rated the average access time at 74.6 ms. This places the drive in a category with those used in the PC/XT and compatibles, rather than in the AT category where a 40-ms access time is normal. The TeleCAT-286's disk controller includes a buffering technique, however, that permits the drive to be formatted with an interleave of one, which increases its effective transfer rate beyond that of the AT's hard disk.

The controller contains 1KB of dual-port RAM that is used for I/O buffering. When programs write to disk, the TeleCAT-286 transfers the data to the RAM buffer on the disk controller. After the first sector has been placed into the RAM buffer, the system can retrieve the next buffer while the controller simultaneously writes the first sector to disk. Read operations are performed in a similar fashion.

With this extra buffering in the disk controller, the TeleCAT-286 can read and write information fast enough so that it can operate effectively with the disk formatted with an interleave of one. Therefore, even though the hard disk is a relatively slow model, its transfer rate is better than that of an AT because the TeleCAT-286 can read or write the same amount of data in fewer revolutions of the disk.

Undoubtedly, cost considerations played a large part in TeleVideo's decision to gain AT-class disk performance via the controller and software instead of by using a faster (and more expensive) disk drive. Not only is the TeleCAT-286's drive less expensive, but it also uses less power, thereby permitting TeleVideo to use just a 140-watt power supply, as opposed to the 192-watt model found in the AT.

Although the positioning of the hard drive on its side is efficient use of space in the system unit, it robs the user of essential feedback because TeleVideo did not make the drive's access light visible from outside the unit. The light can be seen only when the system unit cover is off. The decision to make a front panel without an LED opening was undoubtedly a cost consideration.

Two other items that are missing are a keylock switch and a power indicator light. The absence of the power indicator light is especially unfortunate because the power switch is located on the back panel of the system unit where it is normally impossible to see and hard to find. The TeleCAT-286 has a particularly noisy fan, however, which provides a fairly clear, audible indication of when it is running.

The keyboard is a pleasant surprise. At first glance, it appears to be a generic, low-cost keyboard that could accompany any inexpensive AT compatible. What distinguishes this keyboard are its quick action and positive tactile and audio feedback. While it still does not have the same feel as the original AT keyboard, it is close enough that even the most adamant IBM admirer can become used to it.

The keyboard layout is nearly identical to that of the original AT keyboard, one difference being that the keylock lights are located on the keys themselves rather than at the top of the keyboard. Photo 3 compares the TeleCAT-286 and IBM keyboards. As with the AT, the TeleCAT-286 keyboard plugs into the back of the system unit. It is plug-compatible with the IBM unit, so that users can replace the keyboard with other models if they wish.

The TeleCAT-286 system board has sockets for a full megabyte of memory as well as a serial port (9-pin male connector) and a parallel port (25-pin female connector). The connectors are the same as those used in the AT, and the ports are functionally equivalent. The system board is loaded with configurable options. In addition to the standard switch that chooses monitor type and the amount of system board memory, jumpers on the system board can be used to switch the serial port between COM1 and COM2 and the parallel port between LPT1 and LPT2. One drawback is that these ports cannot be disabled. Photo 4 shows the positions of the two ports located on the rear panel of the system unit.

Also on the rear panel is a processor speed switch that is used to move the processor between 6- and 8-MHz modes. The coprocessor speed can be set to match the CPU (4 MHz with a 6-MHz CPU or 5.33 MHz with an 8-MHz CPU), it can be set to 4.77 MHz regardless of CPU speed, or it can use a custom clock supplied by the user. This may be used, for example, to circumvent a copy protection scheme that allows the CPU to run only at a particular speed but could be enhanced by a faster numeric coprocessor. No software-controlled switching is available.

The TeleCAT-286 has only five expansion slots: one 8-bit slot and four 16-bit slots. The 8-bit slot is normally occupied by the video adapter, and one of the 16-bit slots houses the combination diskette/hard-disk adapter. With a serial port, a parallel port, and sockets for 1MB of memory on the system board, many users will find that the three remaining slots are sufficient for most of their needs.

VIDEO EXTRAS

As might be expected from a manufacturer of terminals such as TeleVideo, the TeleCAT-286 comes equipped with a high-resolution monochrome monitor as standard equipment (see photo 5). The monitor is of excellent quality and has the extra touches that come from years of experience. The screen is large, measuring 13 inches diagonally, and it produces easy-to-read green characters on a nonglare background. The monitor rests on a wide tilt-and-swivel base that makes it especially convenient for use on a desktop with the system unit placed to the side on the floor—the cable provided is long enough to permit such a configuration.

TELEVIDEO TELECAT-286 VITAL STATISTICS

TeleCAT-286: $2,995
512KB memory
Parallel printer interface
Serial interface
High-resolution color graphics board (monochrome and CGA compatible)
13-inch, high-resolution, tilt-and-swivel monitor
Realtime clock
1.2MB diskette drive
20MB hard disk

Display adapters
High-resolution color graphics board (monochrome and CGA compatible)

Memory capacity on system board
1MB

Expansion slots
16-bit: 4
8-bit: 1

Remaining available slots
16-bit: 3
8-bit: 0

Extras available

30MB hard disk	$1,420
360KB diskette drive	$1,300
80287 numeric coprocessor	$ 40
Disk-drive mounting hardware (five at distributors' price)	$ 250

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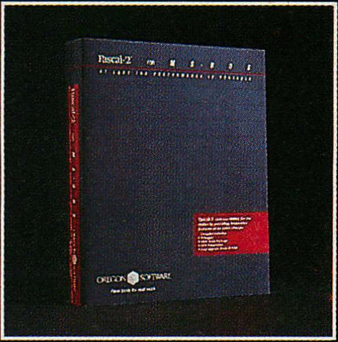

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CIRCLE NO. 143 ON READER SERVICE CARD

TABLE 1: *Video Modes*

MODE	TYPE	NO. OF COLORS	RESOLUTION	COMPATIBLE ADAPTERS	STARTING VIDEO ADDRESS	MEMORY USED (KB)
0	Text	2	40 by 25 chars	CGA	0B8000H	16
1	Text	16	40 by 25 chars	CGA	0B8000H	16
2	Text	16 gray	80 by 25 chars	CGA	0B8000H	16
3	Text	16	80 by 25 chars	CGA	0B8000H	16
4	Graphics	4	320 by 200 dots	CGA	0B8000H	16
5	Graphics	4 gray	320 by 200 dots	CGA	0B8000H	16
6	Graphics	2	640 by 200 dots	CGA	0B8000H	16
7	Text	2	80 by 25 chars	MDA	0B0000H	4
Extended	Graphics	4	320 by 400 dots	None	0B8000H	32
Extended	Graphics	2	640 by 200 dots	None	0B8000H	32
Extended	Graphics	2	640 by 400 dots	None	0B8000H	32
Extended	Graphics	16	640 by 400 dots	None	0A0000H	128

The high-resolution color graphics board is compatible with both IBM's Monochrome Display and Printer Adapter and the CGA.

The TeleVideo monitor does not have a separate power cable; the data cable that plugs into the video card also carries power to the monitor. Although eliminating a cable from the spaghetti wiring that lurks behind most microcomputers is a good idea, the one-cable approach could be dangerous to users who try to connect other monitors to the TeleCAT-286's video card without first reading the manual and setting switches on the card.

The combination of the TeleVideo monitor and high-resolution color graphics board gives the TeleCAT-286 some features not available with the AT. The monochrome monitor, which produces text characters comparable to those of the IBM monochrome display, can be used in graphics mode. The graphics board is compatible with both IBM's Monochrome Display and Printer Adapter and Color Graphics Adapter (CGA). In addition, it provides high-resolution graphics modes not available on either the CGA or Enhanced Graphics Adapter (EGA). Table 1 lists all the video modes supported by the TeleVideo color graphics board.

In the base configuration, the graphics board contains 32KB of video memory. The system uses 4KB of this memory when emulating the monochrome display, starting at address 0B000H (where memory for the IBM monochrome adapter normally resides), and 16KB when emulating the CGA, starting at address 0B800H (where CGA memory normally resides). With this scheme, the graphics board provides direct support for all eight video modes (0-7) used by the monochrome adapter and CGA. Either emulation mode can be switched off to enable the card to coexist with other video cards.

The TeleVideo color graphics board has an 8KB ROM character generation table that provices two different fonts for use in the monochrome-compatible mode (7) and in the CGA-compatible, high-resolution text modes (2 and 3). Both fonts include the standard 256 characters and use an 8-by-16 dot pattern for each character position. The individual characters have a 7-by-9 font size with two descenders.

The two fonts are referred to as single-dot and double-dot. As the name implies, double-dot mode produces wider and fuller characters that look better on TeleVideo's large monitor. However, some uppercase characters (particularly *X*, *Y*, and *Z*) are too wide when displayed in double-dot mode and tend to merge with other wide characters around them. A switch on the graphics board toggles between single-dot and double-dot modes. The switch is conveniently placed at the back edge of the board where it can be accessed from outside the system unit without removing the cover.

The board also has sockets for additional memory, allowing it to contain 128KB of video RAM. When the full complement of memory is installed, the board supports additional text and graphics modes: a 640-by-400 black-and-white mode, a 320-by-400 four-color mode, and a 640-by-400 sixteen-color mode. However, none of these modes is compatible with those provided by IBM's adapters, nor are they compatible with other popular graphics cards, such as those produced by Hercules, Tecmar, or Plantronics. Software that uses these modes would most likely have to come from TeleVideo. The company offers a driver that enables AutoDesk's AutoCAD to use the extended video modes. TeleVideo will make it available to users at no charge upon request.

The monochrome monitor that is supplied with the TeleCAT-286 can display the high-resolution, 640-by-400 black-and-white mode; to display the extended color modes, one of the following color monitors must be used: Taxan 640, Tatung CM-1370, Nanao 8040, or Nanao 7040.

STANDARD SOFTWARE

Both DOS and BASIC are optional with the TeleCAT-286. The unit tested in the article was run under TeleVideo's MS-DOS 3.1 and GW-BASIC 3.1. For the most part, these are standard packages, with several of the DOS commands written by TeleVideo, primarily to support its buffered disk controller and video adapter. The commands that display a TeleVideo copyright include

SYS.COM	KEYBSP.COM
FORMAT.COM	KEYBUK.COM
FDISK.COM	KEYBFR.COM
MODE.COM	DISKCOPY.COM
LABEL.COM	DISKCOMP.COM
GRAFTABL.COM	RESTORE.EXE
GRAPHICS.COM	BACKUP.EXE
KEYBGR.COM	TREE.COM
KEYBIT.COM	

The only items missing from Televideo's DOS package that are included in IBM's DOS are the TopView program information files, BASIC.PIF and BASICA.PIF, and the new DOS 3.2 commands, XCOPY and REPLACE.

Three extra commands are included with TeleVideo DOS that are not part of IBM's DOS package: IDISK.COM, a low-level disk formatting program; PARK.COM, a program that parks the heads on the hard disk in preparation for moving it; and SETUP.COM, a set-up

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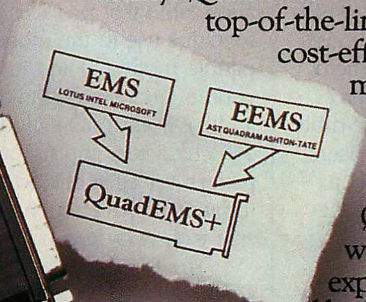

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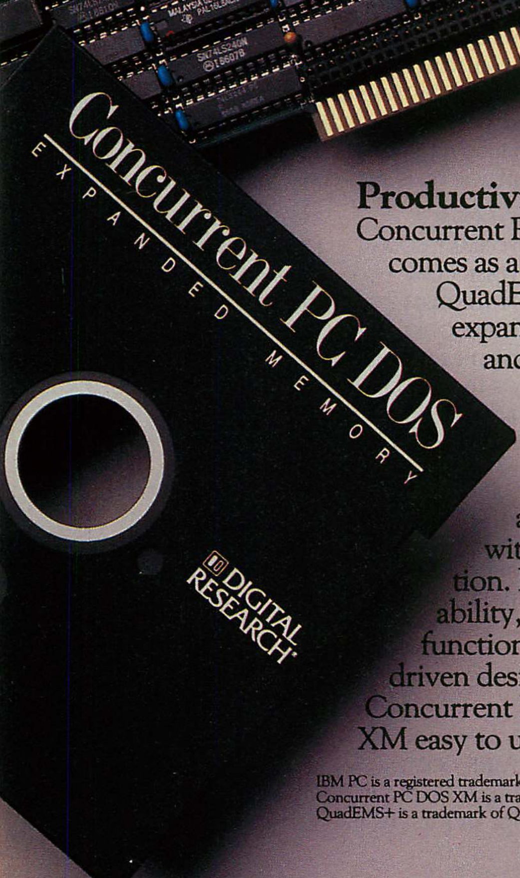

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program that sets the date and time on the battery-powered clock, sets the display adapter and disk drive types, and sets the amount of memory. All of these functions are available on the AT, but in different forms. Parking the heads and setting up machine are functions found on the IBM Diagnostics disk. The low-level formatting program is also included as part of the diagnostics disk. (TeleVideo does not provide any diagnostic programs.) TeleVideo's SETUP.COM is an improvement over the IBM set-up program. It is menu-driven, explains the entire procedure on one screen, and is very easy to use.

TABLE 2: *Hard-disk Types*

TYPE	NO. OF CYLINDERS	NO. OF HEADS	CAPACITY (MB)	LANDING ZONE CYLINDER	WRITE PRECOMPENSATION CYLINDER
1	306	4	10	305	128
2	615	4	20	615	300
3	615	6	31	615	300
4	940	8	63	940	512
5	940	6	47	940	512
6	615	4	20	615	None
7[a]	615	6	31	615	None
8	733	5	31	733	None
9	900	15	114	901	None
10[a]	977	5	41	976	None
11	855	5	36	855	None
12[a]	640	8	43	640	480
13[a]	1,024	8	69	1,024	768
14[a]	1,024	5	43	1,024	768

[a] *These types are not the same as the corresponding IBM PC/AT drive types.*

The installation of third-party hard disks should be performed with care. Special mounting hardware is necessary, and not all of the disk type numbers that are supported are the same as IBM's disk type numbers.

INSTALLING TELECAT

The TeleCAT-286 is as easily installed as most other AT-class machines. The cover of the system unit is fastened with four screws on the rear panel. A medium-sized Phillips screwdriver can be used to remove them and any other screws in the system unit. The cover is a wrap-around type like that of the AT; once the screws have been removed, the cover slides forward and tilts up and off. The front panel is entirely plastic, and although the plastic seems sturdy enough, this is not a cover that should be casually flung across the room after it is removed.

Even though the system unit is small, installing hardware in the TeleCAT-286 is not difficult. The single-width drive storage bay uses a slide-rail mechanism that enable the drives to be removed easily. The slide-rail mechanism is unique to TeleVideo, so third-party drives cannot be installed without adding rails. (This equipment can be purchased separately from TeleVideo distributors or from TeleVideo directly.) Small metal plates fastened with screws on the front panel hold the drives in place, so the user does not need to pull out cards or move cables to reach any screws. A third power connector is tie-wrapped on top of the power supply for use with an additional drive.

Users adding their own hard-disk drives must know which drive types are supported (see table 2). The TeleCAT-286 supports IBM drive types 1 through 6, 8, 9, and 11, but TeleVideo types 7, 10, 12, 13, and 14 are not the same ones supported by the AT.

Although adding an extra drive is easy, removing the vertically mounted hard disk looks next to impossible. The drive is held in place by screws that are accessible only when the drive is removed. If this drive goes bad, the entire system unit probably will need to be taken into the repair shop.

Inserting or removing expansion cards is about as easy as with any other AT-class machine. Plastic card guides are included in the unit. The card area is a tight fit for any cards that are the least bit longer than normal or that have large connectors that must fit through the rear panel. Individual card guides can be popped out to provide more room for these long cards.

Televideo's design makes the TeleCAT's system board fairly accessible. Instead of laying out the board so that the coprocessor slot and RAM sockets can be reached from inside the unit, TeleVideo made the system board itself easy to remove. Seven screws hold it in place: two on the outside of the front panel, two inside by the rear panel, one close to the center of the board, and two on the rear panel attaching the serial and parallel connectors. Any expansion cards must be removed to reach all seven screws. Then the battery, speaker, and power cables must be disconnected, and the system board will slide forward from the lower part of the front panel (see photo 6).

Neither the drives nor the power supply has to be removed in order to take out the system board. Once the board has been removed, memory chips and the numeric coprocessor are easily installed. While the procedure itself is quite simple, some users may have trouble the first time they attempt to remove the board because the user's manual neglects to mention three of the seven screws.

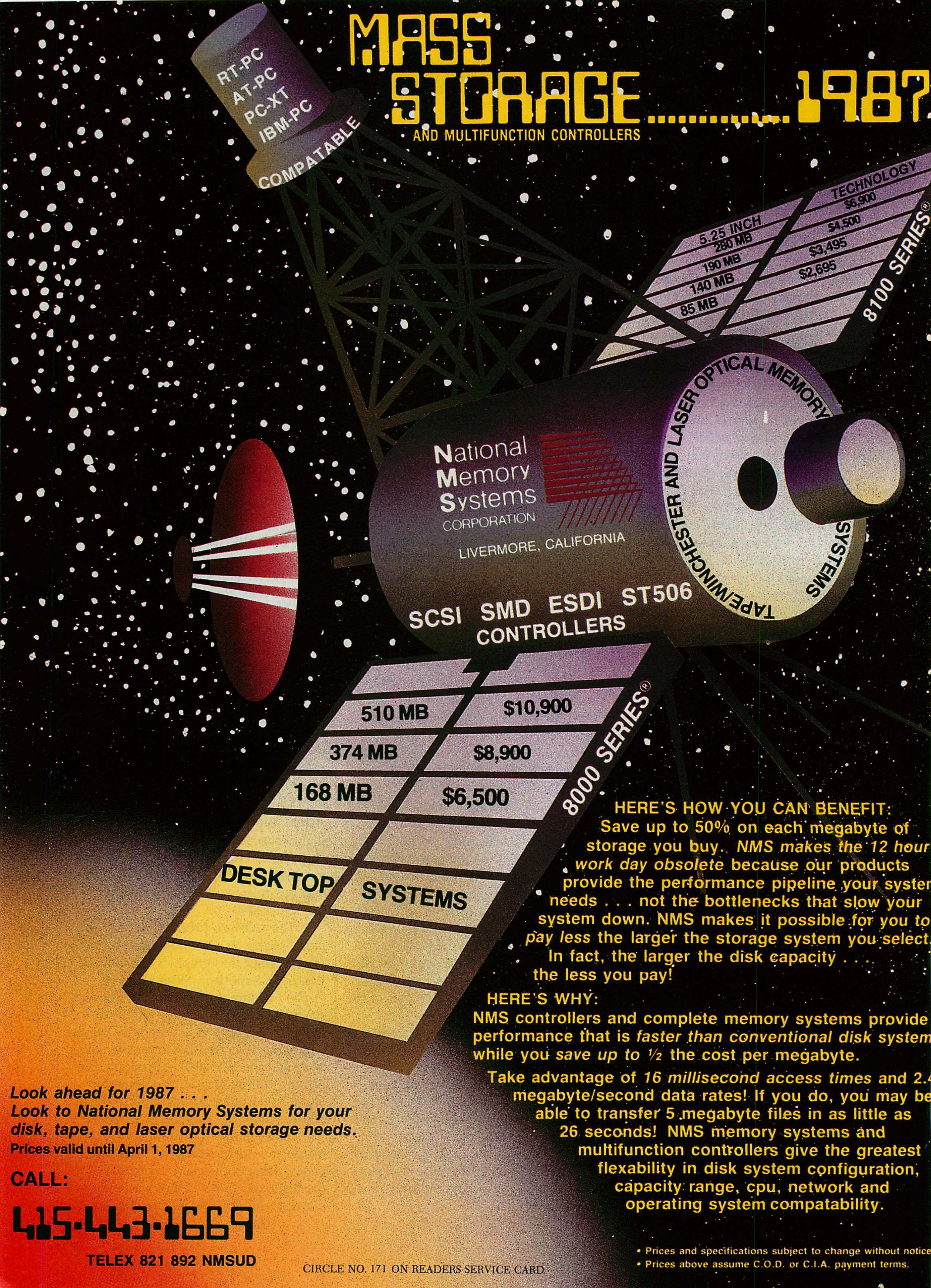
TESTS LEAVE DOUBTS

All of the computers reviewed in this series on AT compatibles undergo two kinds of tests. First, a set of commonly used hardware and software products is installed into the test machine to check for compatibility, and then the *PC Tech Journal* Evaluation Suite for compatibility and performance is run. The results are compared with an 8-MHz AT. See the article "Out from the Shadow of IBM . . .," by Steven Armbrust, Ted Forgeron, and Paul Pierce (August 1986, p. 52) for details on the programs that make up these tests.

The add-on hardware products installed into the TeleCAT-286 for testing include an 80287 numeric coprocessor chip, Intel's Above Board with 4MB of memory, the IBM EGA, Microsoft serial and bus mice, and a Hayes Smartmodem 1200B.

The software products tested include Microsoft's Windows and Word to test the mice and graphics capabilities; Borland's SuperKey, SideKick, and Turbo Lightning to evaluate memory-resident programs; Living Videotext's Ready! to test expanded memory; Hayes' Smartcom II to test the communications port; and the IBM SETUP program and Advanced Diagnostics for a general check-up. A quick run-through with Lotus' Symphony was also performed.

Although this common core of products is always used for testing purposes, new products are often added to the test base. IBM's VDISK was added to the test suite for this article after several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readers pointed out that some AT compatibles either have trouble switching in and out of the 80286's protected mode or they do not use the same mechanism that the AT uses when performing the switch. The VDISK program switches in and out of protected mode to manage extended memory as a virtual disk and, therefore, VDISK seems an ideal candidate for testing the interface. The hard-disk backup program Fastback version 5.13 from Fifth Generation Systems also was added to check the direct memory access (DMA). New hardware packages added to the test suite for this article include the IBM Game Adapter and the Cheetah memory expansion card (to test zero-wait-state memory).

All of hardware products worked as they should, including the IBM Game Adapter and Cheetah card. The EGA, however, required a separate monitor to function properly.

Of the software products tested, IBM Diagnostics disk, Fastback, and Microsoft Word experienced serious problems that leave doubts about the computer's compatibility.

The Fastback restore program worked correctly, but the backup program did not. With the TeleCAT-286 running in 8-MHz mode, the backup never completed successfully. Instead, it exited to DOS, rebooted the computer, or hung the system. When the computer was running at 6 MHz, a backup completed successfully one time out of ten tries, but it still reported the messages "8 hard disk errors" and "8 controller resets" while backing up 19.6MB of data. This casts a dark shadow on the compatibility of the TeleVideo's buffered disk adapter.

When using Word on the TeleCAT-286 the computer was not able to refresh the screen properly. This was apparent when using the spelling checker, which displayed a double-line border around the entire screen. When the proof option was invoked to check a document for spelling errors, part of the border disappeared and one of the characters in the spell menu was missing. The checker worked, but the screen was not displayed properly.

More seriously, the TeleCAT-286 crashed several times when running Microsoft Word, often when repaginating a document. Sometimes a warm reboot would restart the system, but, often, turning the power off and on was necessary to recover. The problems were not regular; sometimes repaginating worked without problems. The crashes occurred often enough, however, to indicate significant compatibility problems. The same operations were performed on the same document without difficulty when using an AT.

Problems also occurred when a menu, usually the spell-checking menu, was left on the screen for a long period of time (10 or 15 minutes) with no selection made. The system locked up and required a reboot. After a reboot, invoking even the DIR command could produce erratic results, such as scrolling the directory diagonally from right to left up the screen. Another reboot would then be necessary.

These problems seem to be related to the video adapter, as was also the case when running the IBM Diagnostics program. Diagnostics thought that the TeleCAT-286 contained both a monochrome adapter and a color/graphics adapter, but the monochrome adapter test failed. Furthermore, the hard-disk test returned the message "1712 error-cause undetermined" on the error detection and correction test, and the diskette test failed the sequential access, random seek, and verify disk tests. The diskette test also thought that the 1.2MB diskette was a 360KB model and returned a "603 diskette size error".

ATBIOS, which checks the BIOS and BIOS data area, shows that the TeleCAT-286 BIOS uses the data area in the same way as the AT.

The five programs that comprise the *PC Tech Journal* AT Evaluation Suite also were run on the TeleCAT-286. Table 3 lists the results.

ATBIOS, which checks the BIOS and BIOS data area, shows that the TeleCAT-286 BIOS uses the data area in the same way that the AT does. The test does not reveal conclusively who designed the BIOS, because TeleVideo's name is the one in the copyright statement and no other readable strings appear in the BIOS address range.

ATPERF measures CPU and numeric coprocessor clock rates, as well as memory access times. It shows that the performance of the TeleCAT-286 is on a par with the 8-MHz AT. Only the CGA video write numbers are worse than the corresponding numbers for the AT. On the TeleCAT-286, the CGA tests measure the performance of TeleVideo's high-performance color/graphics board. Thus, the figures indicate that writing to its video memory is only 75 percent as fast as writing to the CGA memory.

ATFLOAT, which measures floating-point operations with the numeric coprocessor installed, and ATKEY, which checks for keyboard compatibility, both show results equivalent to that of the 8-MHz AT. ATFLOAT shows that the TeleCAT-286 can process floating-point operations at the same speed as the AT. ATKEY verifies keyboard compatibility. The AT keyboard also works when plugged into the TeleCAT-286.

In measuring hard-disk performance, ATDISK provides the most surprising results. As noted earlier, the track-to-track and average seek times show that the TeleCAT-286's hard disk is a slower model than those generally found in AT compatibles, but the effective transfer rate of the disk is almost three times that of an 8-MHz AT. This difference is due to the buffering algorithm used in TeleVideo's disk controller, which allows the disk to be formatted at an interleave of one so that the controller can accept data as fast as it spins by the read head.

The combination of relatively slow head movement and relatively fast transfer rate presents an interesting question of just how good the overall disk performance is when used in a normal environment. The DOS file I/O portion of the ATDISK program provides a partial answer, because it reads and writes 20KB files, thus offering a mix of head positioning and sequential I/O. The results show that the TeleCAT-286's disk performs better than a typical XT-class hard disk but worse than drives that are normally in ATs and compatibles.

However, the results of the DOS file I/O test may not be a true indication of how the TeleCAT-286's disk will perform in all circumstances. Applications that do a lot of seeking to various places on the disk will probably run slower on the TeleCAT-286 than on the AT. On the other hand, applications that read and write large amounts of sequential data might run faster.

GOOD FOR THE PRICE

Also of importance when evaluating the AT compatibles in this series is documentation and support. As might be expected from a manufacturer of low-cost computers, the TeleVideo documentation is not as slick as that provided by the major vendors. The DOS and BASIC manuals both were generated on a letter-quality printer, but are adequately organized and contain the basic set of

TABLE 3: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	TELECAT-286, 20MB DISK
ATBIOS		
ROM BIOS date	11/15/85	06/16/86
ATPERF		
Average RAM instruction fetch (μs)	.403 (100)[b]	.404 (100)
Average RAM read time (μs)		
BYTE	.401 (100)	.402 (100)
WORD	.401 (100)	.402 (100)
Average RAM write time (μs)		
BYTE	.401 (100)	.402 (100)
WORD	.401 (100)	.402 (100)
Average ROM read time (μs)		
BYTE	.401 (100)	.402 (100)
WORD	.401 (100)	.402 (100)
Average video write time (μs) (CGA only)		
BYTE	1.208 (100)	1.691 (75)
WORD	2.415 (100)	3.221 (75)
Average EMM read time (μs)		
BYTE	.402 (100)	.402 (100)
WORD	.402 (100)	.402 (100)
Average EMM write time (μs)		
BYTE	.402 (100)	.402 (100)
WORD	.402 (100)	.402 (100)
CPU clock rate (MHz)	8.0 (100)	8.0 (100)
Math coprocessor clock rate (MHz)	5.3 (100)	5.3 (100)
Refresh overhead (%)	7.1	7.2
RAM read wait states	1	1
RAM write wait states	1	1
ROM read wait states	1	1
Video write wait states (CGA)	8	12
EMM read wait states	1	1
EMM write wait states	1	1
ATFLOAT		
Performance as percentage relative to AT	100	100
ATDISK		
Sectors/track	17	17
Heads	5	4
Cylinders	731	613
Total space (million bytes)	31.81	21.34
Track-track seek time (ms)	6.0	20.5
Average seek time (ms)	37.1	74.6
Effective transfer rate (KB/sec)	170.1	504.1
DOS file I/O (sec)	7.3	9.3
Interleave	3	1

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the TeleCAT-286 are taken only from the review model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal*'s baseline machine, the 8-MHz, 30MB AT.*

The buffering system on the disk controller of the TeleCAT-286 may affect the way the disk performs with different applications. Random-like seeking on the disk will probably run slower on the TeleCAT-286 than on the AT, while it is possible that applications using sequential data might run faster.

reference material. The *User's Manual* obtained for review was a preliminary copy, but it is easy to use; it contains drawings of all the switch and jumper settings, and explains most of the options adequately. The only glaring error is in the installation section, where the manual fails to mention all the screws that hold the system board in place. TeleVideo encloses a postcard for users to send in for the final manual.

TeleVideo offers a standard 90-day parts and service warranty, During that time, users can return computers to their dealers for repair, or they can contact the TeleVideo technical support staff, who will attempt to diagnose the problem over the telephone. No toll-free support line is available, but callers are seldom left hanging on the line waiting for someone to help them.

At the time of this review, TeleVideo was putting the final touches on a new support policy that is one of the best in the PC industry. This policy provides free, on-site support for the first 90 days of ownership from a third-party service organization.

The TeleCAT-286 offers good performance for the money. With 8-MHz performance, built-in serial and parallel ports, a combination monochrome and graphics adapter, and room for 1MB of memory on the system board, this computer can be ideal for the small business or individual on a tight budget. It has room for only three drives and has only three slots available for extra expansion cards, but the TeleCAT-286 offers features that make installing an extra drive, a numeric coprocessor, or extra memory very easy.

The problems experienced using Microsoft Word and Fastback shed doubts on how compatible this computer really is, especially in terms of the video adapter and disk controller. The problems encountered here seem to be subtle ones that might not surface immediately, so potential buyers should perform detailed testing before purchasing the TeleCAT-286.

TeleCAT-286
TeleVideo Systems, Inc.
1170 Morse Avenue
Sunnyvale, CA 94088
408/745-7760
CIRCLE 348 ON READER SERVICE CARD

Steven Armbrust, a freelance technical writer, and Ted Forgeron, software project manager for Intel Scientific Computers, together are the authors of the Programmer's Reference Manual for IBM Personal Computers *(Dow-Jones Irwin). This is their third article in a series on AT-compatible computers.*

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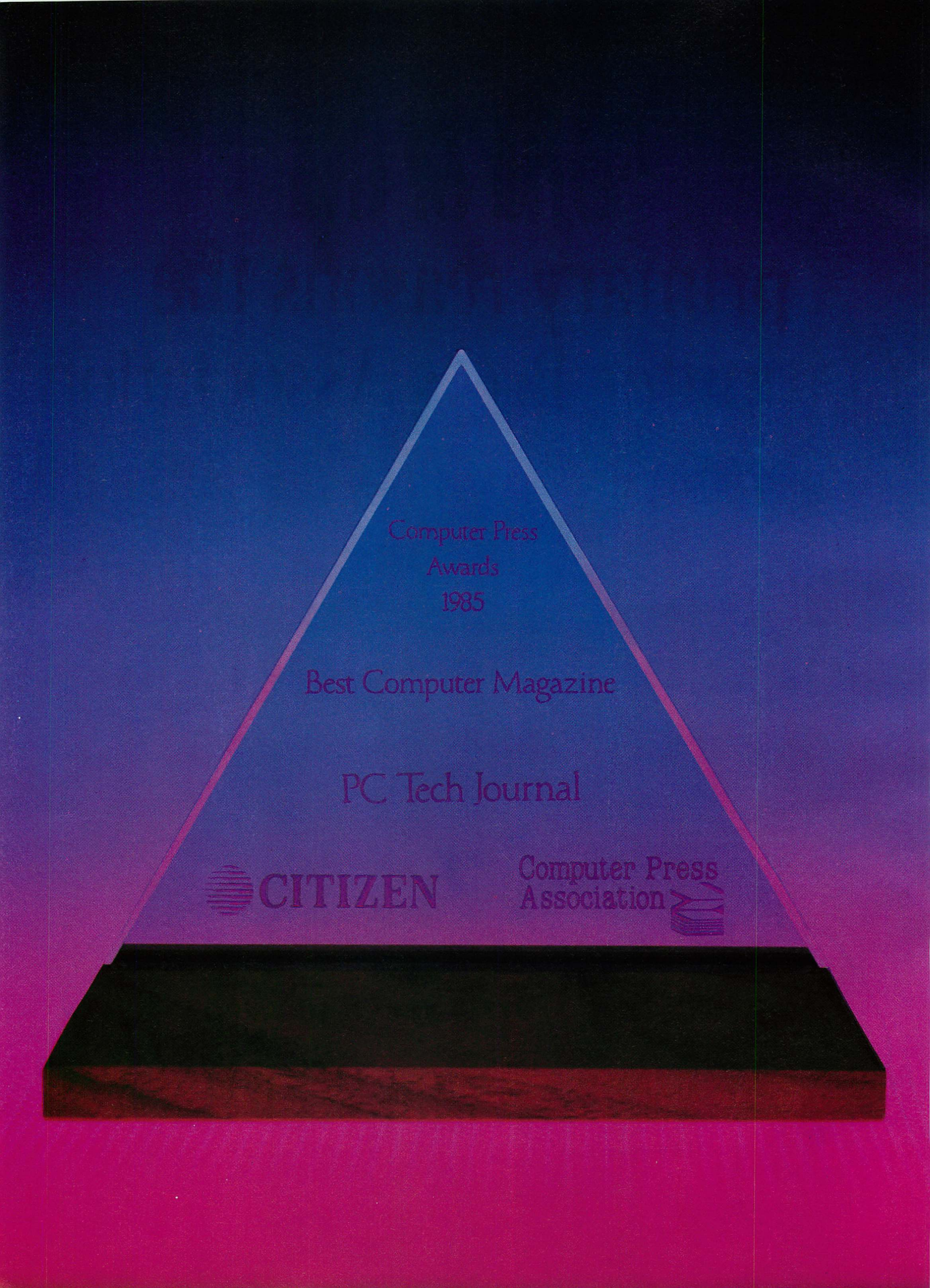
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Display Adapter Bottleneck

Graphics performance may be limited not by CPU clock speed, but rather by display adapter demands on video RAM.

MICHAEL ABRASH

The success of graphics-oriented software depends largely on performance. Whatever other virtues a given graphics package may have, rapid screen handling makes software responsive and satisfying to use, while anything less leaves users frustrated. It is safe to say that the faster the graphics, the better. A logical corollary is that programmers should fight to save processor cycles when they are writing graphics software.

The enemy of speedy graphics operations is the very adapter that displays the graphics. An integral part of the operation of all popular display adapters is the insertion of wait states that can slow graphics operations by a factor of two or more. The PC/AT programmer, in particular, must understand the operation of display adapters, for in the AT a confluence of factors creates a display-memory bottleneck of astonishing impact. Accesses to display memory are significantly different from accesses to normal memory, and the effects of this disparity cannot be taken for granted, especially in display memory-intensive applications such as windowing and icon-based interfaces.

The bottleneck between software and the IBM Enhanced Graphics Adapter in the PC/XT and the AT is not a single, easily quantified event, but rather a dynamic interaction between the processor and display adapter circuitry. Knowledge of the exact mechanism of the bottleneck is far less important than a general understanding of its impact on program performance. Toward that

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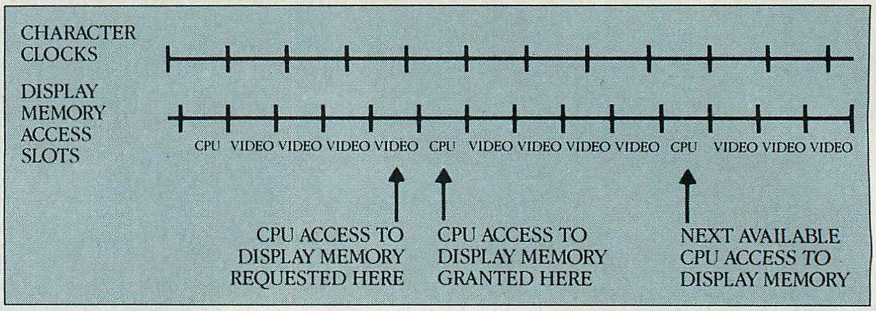
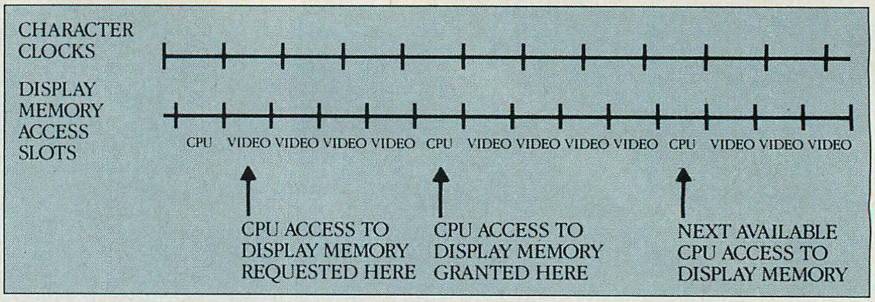
end, the benchmarks in this article provide actual timings that should assist the user in designing effective graphics software. The code used for the timings is modified from "Out From the Shadow of IBM," by Steven Armbrust, Ted Forgeron, and Paul Pierce (August, 1986, p. 52). The results shown in this article were produced by the program that is shown in listings 1 and 2. Listing 1, BOTTLE1.C, was compiled with the Microsoft C compiler 4.0; listing 2, BOTTLE2.ASM, was assembled with the Microsoft Macro Assembler 4.0.

FIGURE 1: *Best-case CPU Display Access*



If the CPU attempts to access display memory just *before* a display memory access that is available for CPU use occurs, then the CPU may have to wait for less than one character clock before the access is allowed.

FIGURE 2: *Worst-case CPU Display Access*



If the CPU attempts to access display memory just *after* a display memory access that is available for CPU use occurs, then the CPU may have to wait for three or more character clocks before the access is allowed.

WAIT STATES

Wait states are signaled to a microprocessor to indicate that the processor should delay completion of the current instruction until some external event has finished. They are a means of telling the CPU to stretch out the current operation to match the relatively slow speed of a peripheral. In the case of the XT, the processor (CPU) is the 8088, and the signaler is typically an add-on card that inserts wait states because it cannot complete an operation as rapidly as the 8088 expects it to.

All of the popular display adapters for the XT, including the EGA, the IBM Color Graphics Adapter (CGA), the Hercules Graphics Card, and the IBM Monochrome Display and Printer Adapter, routinely insert wait states during CPU read and write operations to display memory. The CPU is forced to wait when accessing display memory because it is not the only requester of display memory accesses. The display adapter itself constantly reads display memory in order to obtain the information that controls the pixels displayed on the screen.

To comprehend the tremendous number of display memory reads that must be performed by the display adapter in order to refresh the display, consider in color graphics mode, 60 full screens (frames) are displayed every second. In Mode 10H, the EGA's highest-resolution mode, approximately 28,000 bytes of video data are displayed in each frame.

The EGA's architecture causes the display adapter to demand memory access cycles at the same rate even during the retrace periods, when the adapter does not require video data from display memory. Consequently, additional display memory accesses cycles are lost to the CPU. The resulting 1.5-million-per-second memory accesses performed by the EGA use an extremely large portion of the total memory bandwidth of the EGA. Even in lower-resolution modes, a significant part of the available bandwidth of display memory is used to provide video information. As a result, in all display modes the CPU is forced to wait on each display memory access until one that is free for CPU use becomes available.

Display memory wait states are unavoidable and consume a sizable portion of all available accesses to display memory. The important question is how significant a performance penalty does this impose. The *Technical Reference* manual mentions that, "At least one wait state will be inserted on all memory and I/O accesses from the CPU." True enough, but this statement fails to convey the magnitude of the wait state penalty.

In order to calculate the effect of display memory wait states, the average length of each wait must be determined. This means that the cause of the wait states must be examined. Wait states during CPU accesses to display memory are inserted while the display adapter reads bytes from memory that are needed for video information. The maximum duration of each of these reads is slightly less than one *character clock*, the time required to generate one character on the screen. (In all graphics modes on the EGA, CGA, monochrome, and Hercules adapters, a character clock is the time required to draw eight pixels, the width of a standard character is 640-pixel-wide modes.) If each read by the display adapter took a full character clock, then no memory accesses would be free for CPU use except during retrace times, and CPU memory access would be severely limited. However, graphics adapters are designed so that even in the worst case, the CPU can use at least 20 percent (one out of every five) of the total display memory accesses.

If the display adapter makes one out of every five memory accesses available to the CPU, then the time the CPU has to wait before a given access to display memory is completed depends on the timing of the request relative to the next access that is available to the CPU (see figures 1 and 2). If the CPU requests display memory access just before an available memory access, it may have to wait for less than one character clock, as shown in figure 1. On the other hand, if the CPU requests access just after an available memory access has occurred, it may have to wait for three or more character clocks, as shown in figure 2.

TABLE 1: *XT String Operations, EGA Mode 0EH*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
REP STOSB	N/A	System RAM	258	1.00
	N/A	Display RAM	534	0.48
REP STOSW	N/A	System RAM	361	1.00
	N/A	Display RAM	900	0.40
REP MOVSB	System RAM	System RAM	451	1.00
	System RAM	Display RAM	601	0.75
	Display RAM	Display RAM	901	0.50
REP MOVSW	System RAM	System RAM	655	1.00
	System RAM	Display RAM	1,137	0.58
	Display RAM	Display RAM	1,600	0.41

N/A = Not applicable
Timings were made on an IBM PC/XT at 4.77 MHz, with an EGA in mode 0EH (640 by 200, 16 colors, 14.318-MHz dot clock).

In the PC/XT, access to display RAM is roughly half as fast as to system memory. As all transfers are 8 bits wide, word access exacts less additional penalty.

This random interaction of these two asynchronous events, the character clock and the timing of CPU display memory accesses, means that the effects of wait states are probabilistic and therefore can only be described as averages. On the average, the CPU will have to wait for about two character clocks during a randomly timed memory access to display memory.

The time consumed by wait states on access to video memory is controlled by character clocks, because it is determined by the memory access characteristics and demands of the video data fetching circuitry; the CPU must wait until the video circuitry has finished fetching video data for the moment. This is a key point that looms large in AT operation.

The length of a character clock varies with display mode and character-clock speed. In the 640-by-200 medium-resolution modes of the EGA (modes 06H and 0EH), the dot clock runs at 14.318 MHz so an eight-dot character clock occurs once every 559 nanoseconds. Consequently, the average time the CPU waits on a display memory access is about 1.1 microseconds.

Although 1.1 microseconds does not seem like a long wait, the XT's system clock runs at 4.77 MHz so that the wait time actually amounts to about five CPU wait states—five processor cycles during which the CPU could have been working. This is certainly more significant than "At least one wait state," acknowledged by IBM. For example, because of wait states a REP STOSB instruction, which normally executes in 10 system clock cycles or 2.1 microseconds per byte when writing to nondisplay memory, takes an average of 3.2 microseconds to execute when performed to display memory, approximately 50 percent more slowly than expected. This has important implications for the time required for actions such as screen filling and clearing.

Word accesses to display memory suffer to an even greater extent from the wait state penalty. The 8088 performs word-sized memory accesses as two byte-sized memory accesses, just as if two byte-sized read or write operations had occurred in rapid succession. The first byte written in this manner suffers just as does any other byte-sized memory access, waiting for an available display memory access for two character clocks on average.

The second byte-sized memory access is performed immediately after the first byte access is completed. Unlike the first access, the timing of this memory access is not random with respect to the next display memory access that is available for CPU use. Because the first access has just taken an available display memory access, another display memory access does not become available until four character clocks after the first access. This means that the second byte of a word access to display memory always takes 2.2 microseconds. Only 1.4 microseconds of this time is actually wait state penalty, because slightly more than 0.8 microseconds is required for a normal memory access. Nonetheless, the second byte of every word access to display memory takes more than twice as long as an access to nondisplay memory. In total, the average wait state penalty on a word access to display memory is 2.5 microseconds.

On the XT, the REP STOSW instruction normally executes in 14 CPU cycles per word, or 2.94 microseconds. Access to display adapter memory would seem to be almost twice as slow as access to normal memory. The benchmarks in table 1 show an impact that is actually worse than these estimates. To obtain the timings in table 1, the linked program was run on an IBM EGA in a 4.77-MHz XT. The timings in table 1 indicate that display adapter wait states actually slow REP STOSB by about 2 times and REP STOSW by about 2½ times. The table also shows that REP MOVS is affected to about the same extent as REP STOS; this is the most damaging finding by far for the EGA.

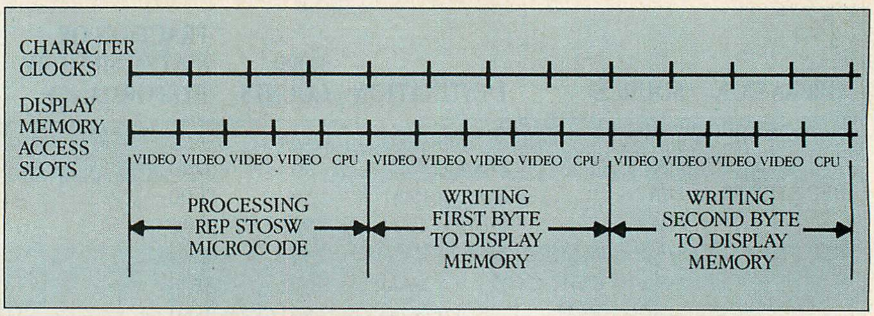
The EGA has enough memory to store more than two full screens in all modes. Predrawn objects, copy buffers, fill patterns, and other bit-mapped data can be stored in the EGA's extra memory. This is particularly advantageous because special hardware in the EGA allows all four planes of EGA memory to be copied with just one CPU read and one CPU write, avoiding the many reads, writes, and OUTs that would be required to copy a multicolored image from system memory to EGA memory. In fact, this is the only reasonably efficient way to manipulate EGA bit maps.

These bit maps are moved as blocks, and REP MOVS is the best instruction for block moves. Unfortunately, as table 1 indicates, block moves with EGA memory as both the source and destination take two or more times as long to execute as would the same block move performed in normal memory. This makes the XT less than ideal for bit-map manipulation, an issue that will recur redoubled regarding the AT.

CONSIDERATIONS AND CAVEATS

The wait state penalties described above are for the worst possible case on the XT, in that they access display memory as rapidly as possible. Most display memory access actually is less intensive, because processing time is required in preparation for display memory access as well as for other program functions. Moreover, not all block moves use video memory for both source and destination. Block moves from system memory to video memory suffer considerably less loss to wait states than do block moves from video memory to video memory. Routines that rely on other than string instructions are likely to be less heavily impacted than the string-oriented benchmark routines, be-

FIGURE 3: *STOSW Display Access Timing*



The major factor in performance when accessing display memory rapidly is the timing of CPU accesses relative to display memory accesses available for CPU use.

cause other instructions do not access memory as frequently as the string instructions do.

The measured impacts of wait states shown in table 1 do not agree exactly with the estimates that were made above. Determining the precise effect of wait states is complex, for two reasons. First, system RAM refresh occurs once every 15 microseconds. Refresh makes all timings approximately 7 percent longer and consequently diminishes the relative impact of wait states. Second, all of the discussion thus far has assumed that CPU accesses to display memory are timed randomly with respect to the next memory access that is available for CPU use. However, instructions such as REP STOSW access memory so rapidly that the timing, in fact, is not random; rather, the CPU synchronizes with the available display memory access slots that become available on every fifth character clock.

In the case of REP STOSW, each word-sized write to memory takes 12 character clocks (three available display memory accesses) or 6.6 microseconds: one display memory access is used for each byte written, and one available memory access is missed while the 8088 processes the microcode for REP STOSW (see figure 3). When refresh occurs once every 2½ STOSW instructions, an additional free memory access is missed. As a result of the interaction of the timing of available display memory accesses and CPU execution times, both bytes written by REP STOSW wait for the full time between available memory accesses, and the effect of wait states is greater than predicted.

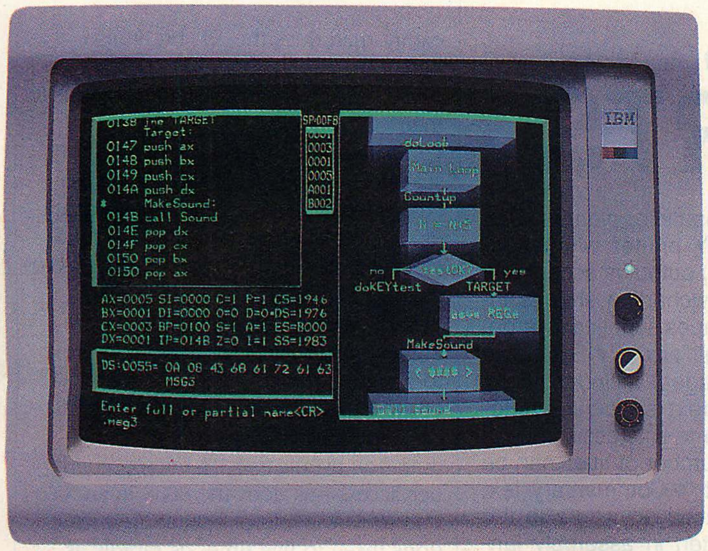
The ultimate result of system refresh, available memory access synchronization, and instruction prefetch is that the effect of wait states is unique for each instruction stream that accesses display memory. Estimates of performance loss for any given instruction stream, therefore, can only be approximate. In addition, different adapters in different modes may run at different character clock speeds and insert different numbers of wait states. For example, the 320-by-200 graphics modes (modes 04H and 0DH) allow the CPU three out of every five display memory access cycles, but run the character clock at only half the speed of the 640-by-200 modes. Timing consistency among compatible adapters is not entirely reliable either; an EGA compatible card that was tested for comparison produced benchmark timings that varied by as much as 8 percent from those that were generated on an IBM EGA.

The resolution/color combination of a given mode does not inherently affect CPU performance when accessing display memory. All that matters is the frequency with which the CPU may access display memory, which derives from the speed of the character clock and the frequency of accesses available to the CPU. This is why modes 06H and 0EH perform identically, even though one provides only 2 colors and the other provides 16 colors.

Text modes rarely require display memory access at a frequency that would make the bottleneck a problem. Wait states, nonetheless, are inserted in text modes as well as in graphics modes. The listings accompanying this article can easily be used to examine text mode wait states, simply by selecting a text mode and the appropriate display memory segment address when prompted; in fact, the impact of the display memory bottleneck in any mode that is supported by the BIOS can be examined similarly.

BOTTLENECK IN THE AT

The video memory access situation goes from serious in the XT to catastrophic in the AT. Not only does the AT suffer from the wait state penalty to a greater



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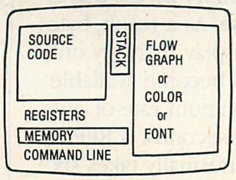

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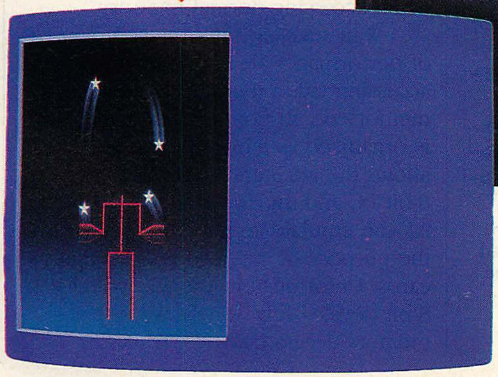
FlowGraph

Color Palette

Font Creation



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extent than does the XT, but it also penalizes display memory accesses because the display adapters are 8- rather than 16-bit devices.

The time consumed by video wait states on any given video memory access is determined by the display adapter's character clock, not by the system clock and not by the CPU's performance characteristics. This means that the higher clock speed of the AT and the higher performance of the 80286 come to naught when accessing video memory, because the 80286 in the AT ends up waiting for the same period of time—an average of 1.1 microseconds per access—as does the 8088 in an XT. The AT is capable of executing instructions three to five times as rapidly as the XT; therefore, the wait state penalty causes far greater graphics performance degradation in this machine.

Repeat string instructions suffer greatly from wait states, because 80286 string instructions execute so rapidly that all accesses after the first one have to wait almost the maximum time for the next display memory access that is available for CPU use. As a result, bytes can be written to display memory only as memory accesses become available to the CPU, at a maximum rate of one byte every 2.2 microseconds. A REP MOVSB instruction normally takes six CPU cycles, or 750 nanoseconds, to work between nondisplay memory in an 8-MHz one-wait-state AT.

When accessing display memory as both source and destination, wait states would cause REP MOVSB to take 4.4 microseconds—2.2 microseconds to read the byte and 2.2 microseconds to write it. This is a total wait state penalty of 3.65 microseconds, slowing the performance by a factor of six. The AT must perform two accesses to display memory in order to write a word, because the display adapter can support the writing of only a single byte at a time. As a result, from wait states alone, REP MOVSW takes twice as long as REP MOVSB. At 8.8 microseconds, this is 11 times slower than the performance when accessing normal memory.

Wait states are not the only source of performance degradation when accessing video memory in an AT. The memory on all popular video adapters is organized as 8-bit-wide memory. This allows the adapters to work in both the 8-bit PC and the 16-bit AT, because the AT can emulate an 8-bit computer for the purpose of supporting PC adapter cards. Unfortunately, the AT accesses 8-bit devices very slowly. A normal memory access takes 3 CPU cycles,

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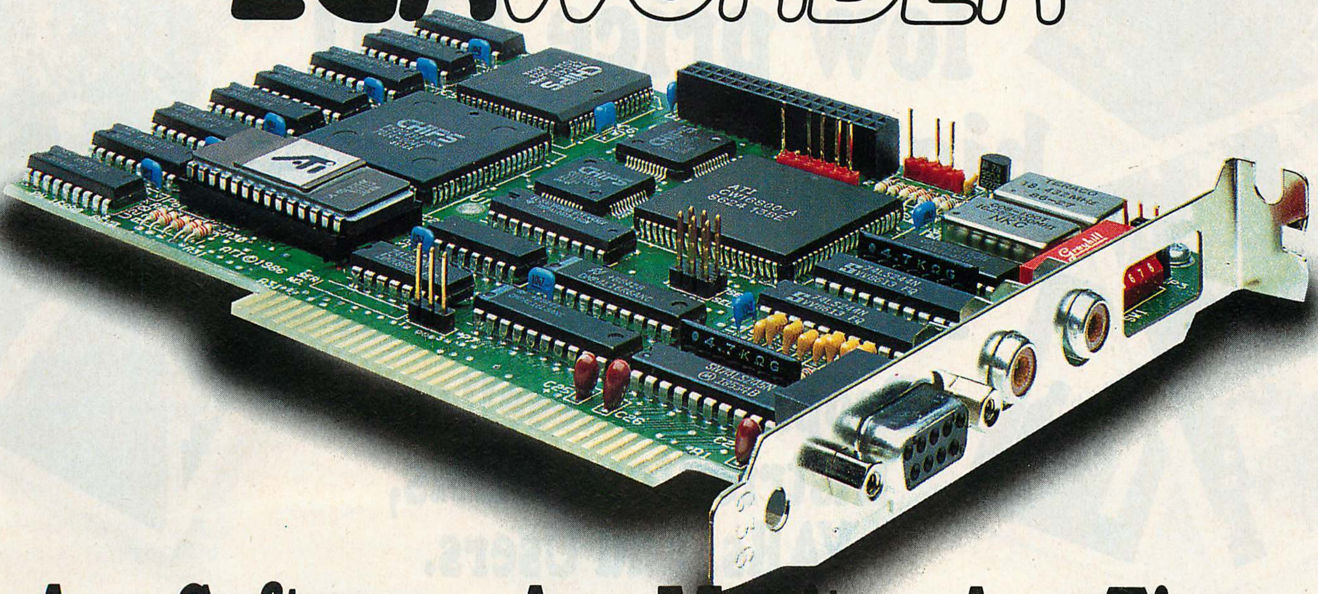

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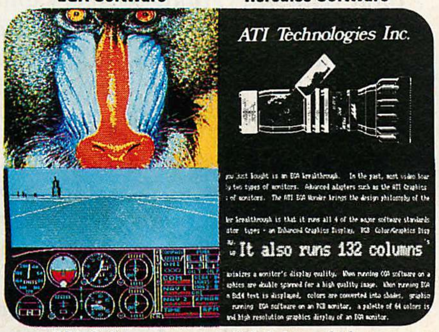

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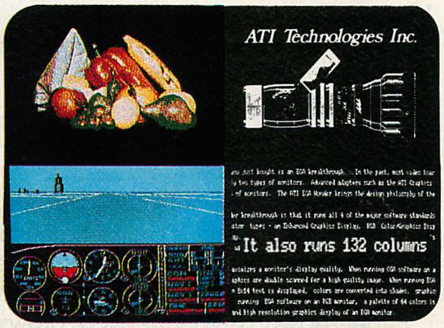

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TABLE 2: *AT String Operations, EGA Mode 0EH*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
REP STOSB	N/A	System RAM	48	1.00
	N/A	Display RAM	267	0.18
REP STOSW	N/A	System RAM	48	1.00
	N/A	Display RAM	533	0.09
REP MOVSB	System RAM	System RAM	96	1.00
	System RAM	Display RAM	313	0.31
	Display RAM	Display RAM	533	0.18
REP MOVSW	System RAM	System RAM	96	1.00
	System RAM	Display RAM	626	0.15
	Display RAM	Display RAM	1,067	0.09

N/A = Not applicable
Timings were made on an IBM PC/AT at 8 MHz, with an EGA in mode 0EH (640 by 200, 16 colors, 14.318-MHz dot clock).

PC/AT word access to 8-bit display RAM is twice as slow as byte access, because the CPU must wait on the display adapter for each byte transfer of each word.

whether the access is byte or word (so long as the word is at an even address) in size. However, a byte access to 8-bit memory takes 6 CPU cycles, and a word access to 8-bit memory takes 12 CPU cycles—four times as long as a word access to 16-bit memory.

Again, the REP MOVSW instruction normally requires only 6 CPU cycles per word, or 750 nanoseconds, to execute. When both the source and destination are video memory, the same instruction takes 24 CPU cycles, or 3.0 microseconds, disregarding wait states.

If the wait state and 8-bit penalties were additive, the performance loss on word-sized block moves from video memory to video memory at 8 MHz would be about 15:1, 11:1 from wait states, and 4:1 from the 8-bit penalty. Table 2 shows the impact on an 8-MHz AT—about 11:1. Astoundingly, an AT is only about 50 percent faster than an XT at manipulating blocks of display memory and a faster processor clock speed will not improve display memory block manipulation performance.

The timings in table 2 imply that for block moves, the 8-bit emulation effect is lost because the emulation overhead occurs during times when the CPU is forced to wait for the next available display memory access anyway. The actual performance loss is about the same as that predicted from wait states alone. For instruction streams that access display memory less intensively, however, the 8-bit emulation effect may have a much greater effect, because the 8-bit emulation effect and the display memory wait states may no longer overlap as completely.

As with the XT, not all video-oriented operations suffer to such a great extent on the AT, since the performance loss is in direct proportion to frequency of video memory access. Still, every display memory access clearly exacts a high price.

PROGRAMMING IMPLICATIONS

The most obvious implication of the display memory bottleneck is that display memory accesses should be minimized to as great an extent as possible. For example, data should be MOVed rather than XORed into display memory whenever possible. The XOR instruction accesses memory twice, once to read the memory operand and once to store the final result. Similarly, buffers should be maintained in system memory rather than in display memory whenever possible. Table 2 indicates that on the AT block moves between system memory and display memory are more than 50 percent faster than block moves involving only display memory.

The importance of minimizing display memory accesses varies with the application. In a dot-plotting routine, for example, the display memory bottleneck can be ignored because more time is spent in calling the routine, calculating the screen offset, and masking and inserting the pixel than is lost to the display memory bottleneck.

Applications that work intensively with blocks of memory are most likely to suffer from the bottleneck. Windowing applications, especially those relying on bit block logical transfer (BITBLT) drivers, are prime candidates for performance loss, although only block

TABLE 3: *XT MOV/LOOP Operations, EGA Mode 0EH*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
MOV/LOOP	System RAM	System RAM	1,543	1.00
(byte)	Display RAM	Display RAM	2,057	0.75
MOV/LOOP	System RAM	System RAM	1,801	1.00
(word)	Display RAM	Display RAM	2,880	0.63

Timings were made on an IBM PC/XT at 4.77 MHz, with an EGA in mode 0EH (640 by 200, 16 colors, 14.318-MHz dot clock).

MOV/LOOP transfers involve considerable CPU and instruction fetch overhead and are thus penalized much less by the display adapter than are string operations.

TABLE 4: *AT MOV/LOOP Operations, EGA Mode 0EH*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
MOV/LOOP	System RAM	System RAM	432	1.00
(byte)	Display RAM	Display RAM	800	0.54
MOV/LOOP	System RAM	System RAM	514	1.00
(word)	Display RAM	Display RAM	1,441	0.36

Timings were made on an IBM PC/AT at 8 MHz, with an EGA in mode 0EH (640 by 200, 16 colors, 14.318-MHz dot clock).

As with string operations, MOV/LOOP access to display RAM suffers more on a PC/AT. Each byte of a word access must wait for an available display RAM access.

moves with the string instructions suffer to the extent shown in tables 1 and 2.

Tables 3 and 4 show the performance loss to the display memory bottleneck on the XT and AT respectively, during a block move performed with the MOV and LOOP instructions. In this instance, the bottleneck slows the performance by a factor of three at the most. While this is certainly significant, it is much less than the penalty of the string-based block move—by a factor of 11. This does not mean that block moves with MOV and LOOP are preferable to block moves performed with the string instructions. It does mean that the string instructions do not have the same advantage over the rest of the 8088 instruction set when accessing display memory that they usually do.

An astute programmer can improve overall program performance considerably by designing code that attempts to access memory only about as often as a display memory access becomes available to the CPU, performing other useful work between accesses. The disadvantage of such an approach is that it is highly dependent on the performance characteristics of both the computer and the display adapter. However, similar hardware-specific approaches to CGA display memory access have been taken in the past when speed was the overriding issue (see "Instant Screens," Augie Hansen, June 1986, p. 96).

The findings in this article are for specific code in specific configurations; different circumstances may not produce similar findings and will likely have different programming implications. These timings are not comprehensive. When working with display memory—as is often the case with the IBM PC family—the only way to be sure of the performance of any code is to time it in the target environment in order to obtain performance measurements relevant to individual applications. This article gives an idea of what to look for and how to measure it.

For example, tables 5 and 6 provide the same timings as tables 1 and 2, except that these timings were performed in the EGA's highest-resolution mode, mode 10H. Logically, the wait time in mode 10H might be assumed to be less than the wait time in mode 6 by the ratio of their dot clocks—16.257 MHz to 14.318 MHz or 13.5 percent faster—because character clocks and therefore available CPU accesses to display memory would occur proportionately more frequently in mode 10. The tables, however, show that while the wait times for some tests do indeed

TABLE 5: *XT String Operations, EGA Mode 10H*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
REP STOSB	N/A	System RAM	258	1.00
	N/A	Display RAM	473	0.55
REP STOSW	N/A	System RAM	361	1.00
	N/A	Display RAM	772	0.47
REP MOVSB	System RAM	System RAM	451	1.00
	System RAM	Display RAM	705	0.64
	Display RAM	Display RAM	942	0.48
REP MOVSW	System RAM	System RAM	655	1.00
	System RAM	Display RAM	983	0.67
	Display RAM	Display RAM	1,544	0.42

N/A = Not applicable
Timings were made on an IBM PC/XT at 4.77 MHz, with an EGA in mode 10H (640 by 350, 16 colors, 16.237-MHz dot clock).

The mode 10H dot clock is 13 percent faster than the 0EH dot clock, but mode 10H string operation performance does not improve proportionately on the PC/XT.

TABLE 6: *AT String Operations, EGA Mode 10H*

OPERATION	SOURCE	DESTINATION	1,000 COUNTS	FRACTION OF SYSTEM MEMORY PERFORMANCE
REP STOSB	N/A	System RAM	48	1.00
	N/A	Display RAM	270	0.18
REP STOSW	N/A	System RAM	48	1.00
	N/A	Display RAM	540	0.09
REP MOVSB	System RAM	System RAM	96	1.00
	System RAM	Display RAM	270	0.36
	Display RAM	Display RAM	540	0.18
REP MOVSW	System RAM	System RAM	96	1.00
	System RAM	Display RAM	540	0.18
	Display RAM	Display RAM	1,080	0.09

N/A = Not applicable
Timings were made on an IBM PC/AT at 8 MHz, with an EGA in mode 10H (640 by 350, 16 colors, 16.237-MHz dot clock).

String operation performance in mode 10H on the PC/AT is virtually identical to AT performance in mode 0EH, implying that the dot clock rate matters very little.

decrease by more than 20 percent, other wait times decrease to a lesser degree, and still others actually increase.

A final implication of the display memory bottleneck is that the AT does not provide the expected performance boost relative to the XT for heavily display-oriented applications. The AT certainly is faster, primarily because not all processing time is spent accessing display memory, but the improvement may be disappointing. The proper solution in the case of the AT is the development of 16-bit display adapters that support more intensive CPU access to display memory. This is particularly desirable because of the proliferation of bit-mapped graphics interfaces that require an AT for good performance.

Instructions that access display memory encounter barriers that are not readily apparent yet highly significant. Performance degradation that is due to display memory access is so great for the AT that until 16-bit display adapters or adapters with dedicated coprocessors come into wide use, graphics performance may be considered a serious weak point of the AT. Effective graphics programming for the IBM family demands all the understanding of this weakness—and clever coding—that can be brought to bear.

Michael Abrash is a senior software engineer for Orion instruments of Redwood City, CA, a manufacturer of PC-based instrumentation and microprocessor development systems.

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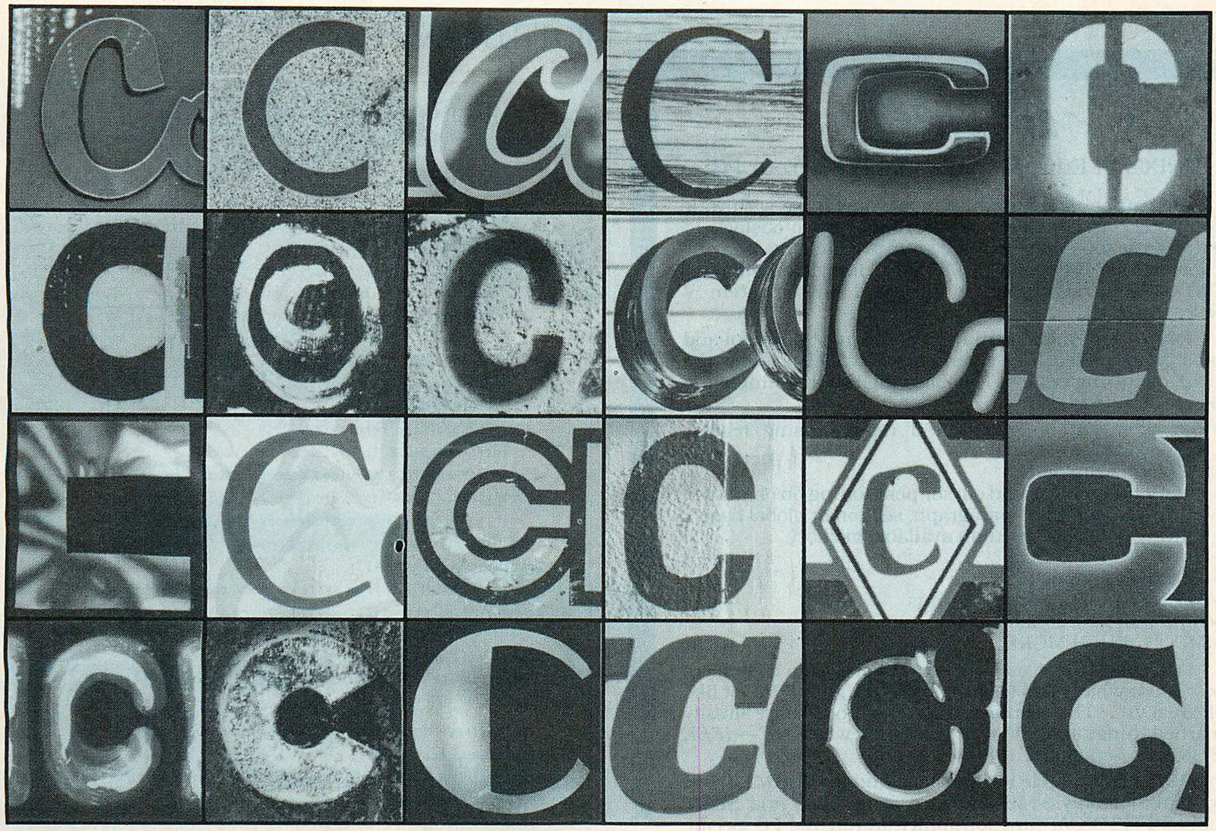
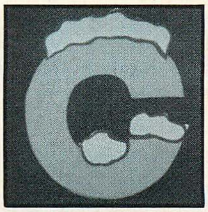
LISTING 1: BOTTLE1.C

```
/*
 *      Listing 1.
 *
 * Video memory access benchmark program.
 *
 * Determines relative speed of access to video memory and system
 * memory in IBM PC, XT, AT.
 *
 * Last modified 10/25/86
 * Program by: Michael Abrash
 *
 * Modified from listings in "Out From the Shadow of IBM," by
 * Steven Armbrust, Ted Forgeron, and Paul Pierce,
 * PC Tech Journal, August, 1986.
 *
 * Compiled with Microsoft C version 4.0.
 * Listing 2 must be linked to this program:
 *
 * MSC BOTTLE1;
 * MASM BOTTLE2;
 * LINK BOTTLE1+BOTTLE2;
 *
 * Be sure to use LINK V3.0 or later.
 */

#include <dos.h>

/* Number of different timings to take */
#define VARS    14

/* Number of memory accesses to perform per timing test */
#define COUNT 1000

/* Number of times to repeat timing test */
#define TRIALS 100

char far test_segment[0x8000],
     far *ptr_test_segment = test_segment;

/*
 * Main program.
 */
main()
{
    int i;
    int count;   /* number of memory accesses per timing test */
    int trials;  /* number of times to repeat each timing test */
    int mode;                   /* video mode */
    unsigned int video_segment;   /* video access test segment */
    long acctime[VARS];  /* total time consumed by timing test */
    union REGS inregs, outregs;

    /* Prompt for video mode and segment */
    printf("Video mode to test in:");
    scanf("%d",&mode);
    printf("Video segment to test at:");
    scanf("%x",&video_segment);

    /* Set video mode */
    inregs.x.ax = mode;
    int86(0x10, &inregs, &outregs);

    count = COUNT;
    trials = TRIALS;

    /* Clear accumulated times */
    for ( i = 0; i < VARS; i++ )
        acctime[i] = 0;

    /* Repeat timing tests to accumulate time consumed */
    for ( i= 0; i < trials; i++ ) {
      acctime[0] += bstotime(count, FP_SEG(ptr_test_segment));
      acctime[1] += bstotime(count, video_segment);
      acctime[2] += wstotime(count, FP_SEG(ptr_test_segment));
      acctime[3] += wstotime(count, video_segment);
      acctime[4] += bmvstime(count, FP_SEG(ptr_test_segment),
                    FP_SEG(ptr_test_segment));
      acctime[5] += bmvstime(count, FP_SEG(ptr_test_segment),
                    video_segment);
```

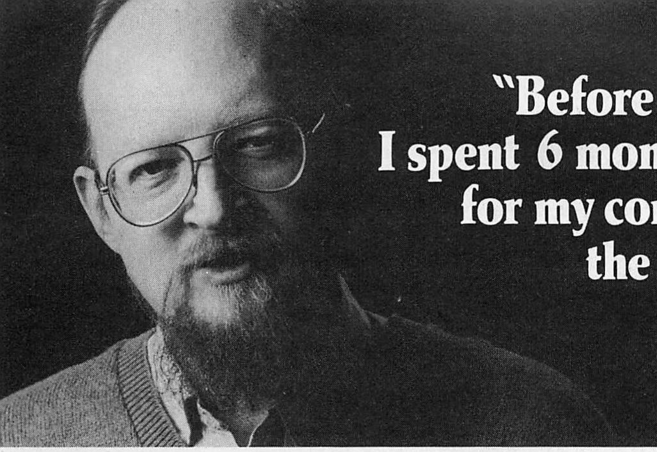




```
        acctime[6] += bmvstime(count, video_segment, video_segment);
        acctime[7] += wmvstime(count, FP_SEG(ptr_test_segment),
                               FP_SEG(ptr_test_segment));
        acctime[8] += wmvstime(count, FP_SEG(ptr_test_segment),
                               video_segment);
        acctime[9] += wmvstime(count, video_segment, video_segment);
        acctime[10] += bmvtime(count, FP_SEG(ptr_test_segment),
                               FP_SEG(ptr_test_segment));
        acctime[11] += bmvtime(count, video_segment, video_segment);
        acctime[12] += wmvtime(count, FP_SEG(ptr_test_segment),
                               FP_SEG(ptr_test_segment));
        acctime[13] += wmvtime(count, video_segment, video_segment);
    }

    /* Display the results */
    printf("REP STOSB to system memory: %ld counts.\n", acctime[0]);
    printf("REP STOSB to video memory : %ld counts.\n", acctime[1]);
    printf("REP STOSW to system memory: %ld counts.\n", acctime[2]);
    printf("REP STOSW to video memory : %ld counts.\n", acctime[3]);
    printf("REP MOVSB from system memory to system memory: \
%ld counts.\n", acctime[4]);
    printf("REP MOVSB from system memory to video memory : \
%ld counts.\n", acctime[5]);
    printf("REP MOVSB from video memory to video memory  : \
%ld counts.\n", acctime[6]);
    printf("REP MOVSW from system memory to system memory: \
%ld counts.\n", acctime[7]);

    printf("REP MOVSW from system memory to video memory : \
%ld counts.\n", acctime[8]);
    printf("REP MOVSW from video memory to video memory  : \
%ld counts.\n", acctime[9]);
    printf("MOV/LOOP byte from system memory to system memory  : \
%ld counts.\n", acctime[10]);
    printf("MOV/LOOP byte from video memory to video memory  : \
%ld counts.\n", acctime[11]);
    printf("MOV/LOOP word from system memory to system memory  : \
%ld counts.\n", acctime[12]);
    printf("MOV/LOOP word from video memory to video memory  : \
%ld counts.\n", acctime[13]);

}
```

LISTING 2: BOTTLE2.ASM

```
;
; Listing 2.
;
; Modified from listings in "Out From the Shadow of IBM," by
; Steven Armbrust, Ted Forgeron, and Paul Pierce,
; PC Tech Journal, August, 1986.
;
; Assembled with Microsoft Assembler version 4.0.
;
        NAME    TIME
_TEXT   SEGMENT BYTE PUBLIC 'CODE'
_TEXT   ENDS
CONST   SEGMENT WORD PUBLIC 'CONST'
CONST   ENDS
_BSS    SEGMENT WORD PUBLIC 'BSS'
_BSS    ENDS
_DATA   SEGMENT WORD PUBLIC 'DATA'
_DATA   ENDS
DGROUP  GROUP   CONST, _BSS, _DATA
        ASSUME  CS: _TEXT, DS: DGROUP, SS: DGROUP, ES: DGROUP

TESTSEG SEGMENT WORD PUBLIC 'TEST'

TESTSEG_START   DW      32767 DUP (?)

TESTSEG ENDS

PPI_PORT        EQU     061H
TIMER2_PORT     EQU     042H
TIMER_CTRL      EQU     043H

_TEXT   SEGMENT
```



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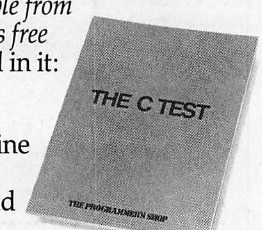

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```
;***************************************************************;
;                                                               ;
;       _BSTOTIME                                               ;
;       TIME EXECUTION OF REP STOSB INSTRUCTION                 ;
;                                                               ;
;***************************************************************;
        PUBLIC  _BSTOTIME
_BSTOTIME       PROC    NEAR
        PUSH    BP                      ; SAVE FRAME
        MOV     BP, SP                  ;
        PUSH    ES                      ; SAVE ES
        PUSH    DI                      ; SAVE DI
        CALL    SETUP_TIMER             ; SET UP TIMER
        MOV     CX, [BP+4]              ; GET COUNT ARGUMENT
        MOV     DI,0
        MOV     ES, [BP+6]              ; ES:DI -> TEST BUFFER
        IN      AL, PPI_PORT            ; GET CURRENT CONTROL
        MOV     BL,AL                   ; SAVE IN BL
        OR      AX, 1                   ; SET TIMER ENABLE BIT
        CLI                             ; STOP INTERRUPTS
        CLD                             ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL            ; ENABLE TIMER
        REP STOSB                       ; RUN TEST
        MOV     AL, BL                  ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL            ;
        STI                             ; START INTERRUPTS
        CALL    GET_TIMER               ; OBTAIN FINAL COUNT
        POP     DI                      ; RESTORE DI
        POP     ES                      ; RESTORE ES
        POP     BP                      ; RESTORE BP
        RET                             ; RETURN
_BSTOTIME       ENDP
;***************************************************************;
;                                                               ;
;       _WSTOTIME                                               ;
;       TIME EXECUTION OF REP STOSW INSTRUCTION                 ;
;                                                               ;
;***************************************************************;
        PUBLIC  _WSTOTIME
_WSTOTIME       PROC    NEAR
        PUSH    BP                      ; SAVE FRAME
        MOV     BP, SP                  ;
        PUSH    ES                      ; SAVE ES
        PUSH    DI                      ; SAVE DI
        CALL    SETUP_TIMER             ; SET UP TIMER
        MOV     CX, [BP+4]              ; GET COUNT ARGUMENT
        MOV     DI,0
        MOV     ES, [BP+6]              ; ES:DI -> TEST BUFFER
        IN      AL, PPI_PORT            ; GET CURRENT CONTROL
        MOV     BL,AL                   ; SAVE IN BL
        OR      AX, 1                   ; SET TIMER ENABLE BIT
        CLI                             ; STOP INTERRUPTS
        CLD                             ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL            ; ENABLE TIMER
        REP STOSW                       ; RUN TEST
        MOV     AL, BL                  ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL            ;
        STI                             ; START INTERRUPTS
        CALL    GET_TIMER               ; OBTAIN FINAL COUNT
        POP     DI                      ; RESTORE DI
        POP     ES                      ; RESTORE ES
        POP     BP                      ; RESTORE BP
        RET                             ; RETURN
_WSTOTIME       ENDP
;***************************************************************;
;                                                               ;
;       _BMVSTIME                                               ;
;       TIME EXECUTION OF REP MOVSB INSTRUCTION                 ;
;                                                               ;
;***************************************************************;
        PUBLIC  _BMVSTIME
_BMVSTIME       PROC    NEAR
        PUSH    BP                      ; SAVE FRAME
        MOV     BP, SP                  ;
        PUSH    DS                      ; PUSH DS
        PUSH    ES                      ; SAVE ES
        PUSH    SI                      ; SAVE SI
        PUSH    DI                      ; SAVE DI
        CALL    SETUP_TIMER             ; SET UP TIMER
        MOV     CX, [BP+4]              ; GET COUNT ARGUMENT
        MOV     DI, 0
        MOV     SI, DI
        MOV     DS, [BP+6]              ; DS:SI -> SOURCE BUFFER
        MOV     ES, [BP+8]              ; ES:DI -> DEST. BUFFER
        IN      AL, PPI_PORT            ; GET CURRENT CONTROL
        MOV     BL,AL                   ; SAVE IN BL
        OR      AX, 1                   ; SET TIMER ENABLE BIT
        CLI                             ; STOP INTERRUPTS
        CLD                             ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL            ; ENABLE TIMER
        REP MOVSB                       ; RUN TEST
        MOV     AL, BL                  ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL            ;
        STI                             ; START INTERRUPTS
        CALL    GET_TIMER               ; OBTAIN FINAL COUNT
        POP     DI                      ; RESTORE DI
        POP     SI                      ; RESTORE SI
        POP     ES                      ; RESTORE ES
        POP     DS                      ; RESTORE DS
        POP     BP                      ; RESTORE BP
        RET                             ; RETURN
_BMVSTIME       ENDP
;***************************************************************;
;                                                               ;
;       _WMVSTIME                                               ;
;       TIME EXECUTION OF REP MOVSW INSTRUCTION                 ;
;       FROM SYSTEM MEMORY TO SYSTEM MEMORY                     ;
;                                                               ;
;***************************************************************;
        PUBLIC  _WMVSTIME
_WMVSTIME       PROC    NEAR
        PUSH    BP                      ; SAVE FRAME
        MOV     BP, SP                  ;
        PUSH    DS                      ; PUSH DS
        PUSH    ES                      ; SAVE ES
        PUSH    SI                      ; SAVE SI
        PUSH    DI                      ; SAVE DI
        CALL    SETUP_TIMER             ; SET UP TIMER
        MOV     CX, [BP+4]              ; GET COUNT ARGUMENT
        MOV     DI, 0
        MOV     SI, DI
        MOV     DS, [BP+6]              ; DS:SI -> SOURCE BUFFER
        MOV     ES, [BP+8]              ; ES:DI -> DEST. BUFFER
        IN      AL, PPI_PORT            ; GET CURRENT CONTROL
        MOV     BL,AL                   ; SAVE IN BL
        OR      AX, 1                   ; SET TIMER ENABLE BIT
        CLI                             ; STOP INTERRUPTS
        CLD                             ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL            ; ENABLE TIMER
        REP MOVSW                       ; RUN TEST
        MOV     AL, BL                  ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL            ;
        STI                             ; START INTERRUPTS
        CALL    GET_TIMER               ; OBTAIN FINAL COUNT
        POP     DI                      ; RESTORE DI
        POP     SI                      ; RESTORE SI
        POP     ES                      ; RESTORE ES
        POP     DS                      ; RESTORE DS
        POP     BP                      ; RESTORE BP
        RET                             ; RETURN
_WMVSTIME       ENDP
;***************************************************************;
;                                                               ;
;       _BMVTIME                                                ;
;       TIME EXECUTION OF MOV/LOOP BYTE                         ;
;                                                               ;
;***************************************************************;
        PUBLIC  _BMVTIME
_BMVTIME        PROC    NEAR
        PUSH    BP                      ; SAVE FRAME
        MOV     BP, SP                  ;
        PUSH    DS                      ; PUSH DS
        PUSH    ES                      ; SAVE ES
        PUSH    SI                      ; SAVE SI
        PUSH    DI                      ; SAVE DI
        CALL    SETUP_TIMER             ; SET UP TIMER
        MOV     CX, [BP+4]              ; GET COUNT ARGUMENT
        MOV     DI, 0
        MOV     SI, DI
```

```
        MOV     DS, [BP+6]          ; DS:SI -> SOURCE BUFFER
        MOV     ES, [BP+8]          ; ES:DI -> DEST. BUFFER
        IN      AL, PPI_PORT        ; GET CURRENT CONTROL
        MOV     BL,AL               ; SAVE IN BL
        OR      AX, 1               ; SET TIMER ENABLE BIT
        CLI                         ; STOP INTERRUPTS
        CLD                         ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL        ; ENABLE TIMER
BMVLP:
        MOV     AL,[SI]             ; RUN TEST
        MOV     ES:[DI],AL
        INC     SI
        INC     DI
        LOOP    BMVLP
        MOV     AL, BL              ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL        ;
        STI                         ; START INTERRUPTS
        CALL    GET_TIMER           ; OBTAIN FINAL COUNT
        POP     DI                  ; RESTORE DI
        POP     SI                  ; RESTORE SI
        POP     ES                  ; RESTORE ES
        POP     DS                  ; RESTORE DS
        POP     BP                  ; RESTORE BP
        RET                         ; RETURN
_BMVTIME        ENDP
;*****************************************************************;
;                                                                 ;
;       _WMVTIME                                                  ;
;       TIME EXECUTION OF MOV/LOOP WORD                           ;
;                                                                 ;
;*****************************************************************;
        PUBLIC  _WMVTIME
_WMVTIME        PROC    NEAR
        PUSH    BP                  ; SAVE FRAME
        MOV     BP, SP              ;
        PUSH    DS                  ; PUSH DS
        PUSH    ES                  ; SAVE ES
        PUSH    SI                  ; SAVE SI
        PUSH    DI                  ; SAVE DI
        CALL    SETUP_TIMER         ; SET UP TIMER
        MOV     CX, [BP+4]          ; GET COUNT ARGUMENT
        MOV     DI, 0
        MOV     SI, DI
        MOV     DS, [BP+6]          ; DS:SI -> SOURCE BUFFER
        MOV     ES, [BP+8]          ; ES:DI -> DEST. BUFFER
        IN      AL, PPI_PORT        ; GET CURRENT CONTROL
        MOV     BL,AL               ; SAVE IN BL
        OR      AX, 1               ; SET TIMER ENABLE BIT
        CLI                         ; STOP INTERRUPTS
        CLD                         ; SET FORWARD DIRECTION
        OUT     PPI_PORT, AL        ; ENABLE TIMER
WMVLP:
        MOV     AX,[SI]             ; RUN TEST
        MOV     ES:[DI],AX
        INC     SI
        INC     SI
        INC     DI
        INC     DI
        LOOP    WMVLP
        MOV     AL, BL              ; RESTORE CONTROL VALUE
        OUT     PPI_PORT, AL        ;
        STI                         ; START INTERRUPTS
        CALL    GET_TIMER           ; OBTAIN FINAL COUNT
        POP     DI                  ; RESTORE DI
        POP     SI                  ; RESTORE SI
        POP     ES                  ; RESTORE ES
        POP     DS                  ; RESTORE DS
        POP     BP                  ; RESTORE BP
        RET                         ; RETURN
_WMVTIME        ENDP
;*****************************************************************;
;                                                                 ;
;       SETUP_TIMER                                               ;
;       SET UP THE TIMER FOR MAXIMUM COUNT, TO TIME A RUN         ;
;                                                                 ;
;*****************************************************************;
SETUP_TIMER     PROC    NEAR
        PUSH    AX                  ; SAVE AX
        IN      AL, PPI_PORT        ; STOP THE TIMER
        AND     AL, 0FCH            ;
        OUT     PPI_PORT, AL        ;
        MOV     AL, 0B4H            ; INITIALIZE THE TIMER
        OUT     TIMER_CTRL, AL      ;
        MOV     AL, 0               ; CLEAR THE COUNT
        OUT     TIMER2_PORT, AL     ;
        NOP                         ;
        OUT     TIMER2_PORT, AL     ;
        POP     AX                  ; RESTORE AX
        RET                         ; RETURN
SETUP_TIMER     ENDP
;*****************************************************************;
;                                                                 ;
;       GET_TIMER                                                 ;
;       TAKE THE COUNT FROM THE TIMER                             ;
;                                                                 ;
;*****************************************************************;
GET_TIMER       PROC    NEAR
        PUSH    BX                  ; SAVE REGISTERS
        IN      AL, TIMER2_PORT     ; GET LOW BYTE OF TIME
        MOV     AH, AL              ;
        IN      AL, TIMER2_PORT     ; GET HIGH BYTE
        XCHG    AL,AH               ; TIME IN AX
        NEG     AX                  ; CORRECT FOR COUNT-DOWN
        POP     BX                  ; RESTORE REGISTERS
        RET                         ; RETURN
GET_TIMER       ENDP

_TEXT   ENDS
        END
```

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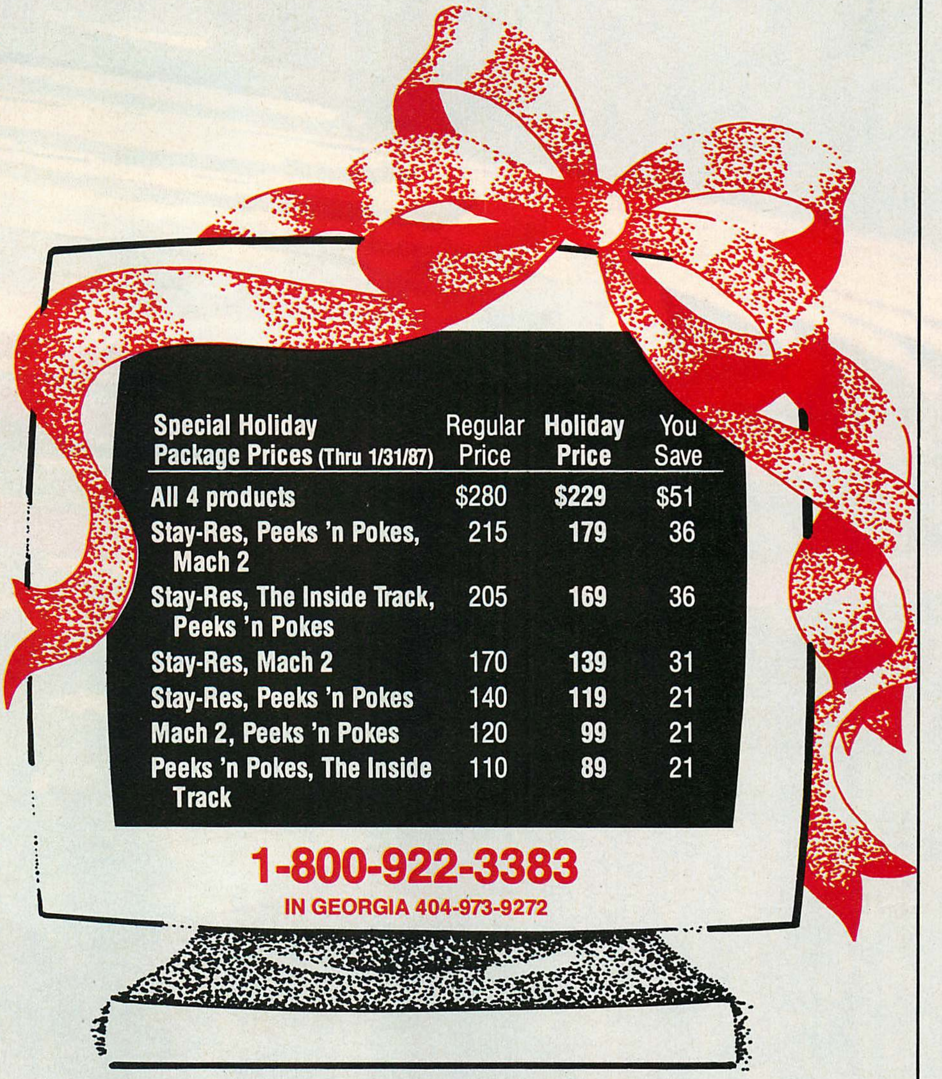

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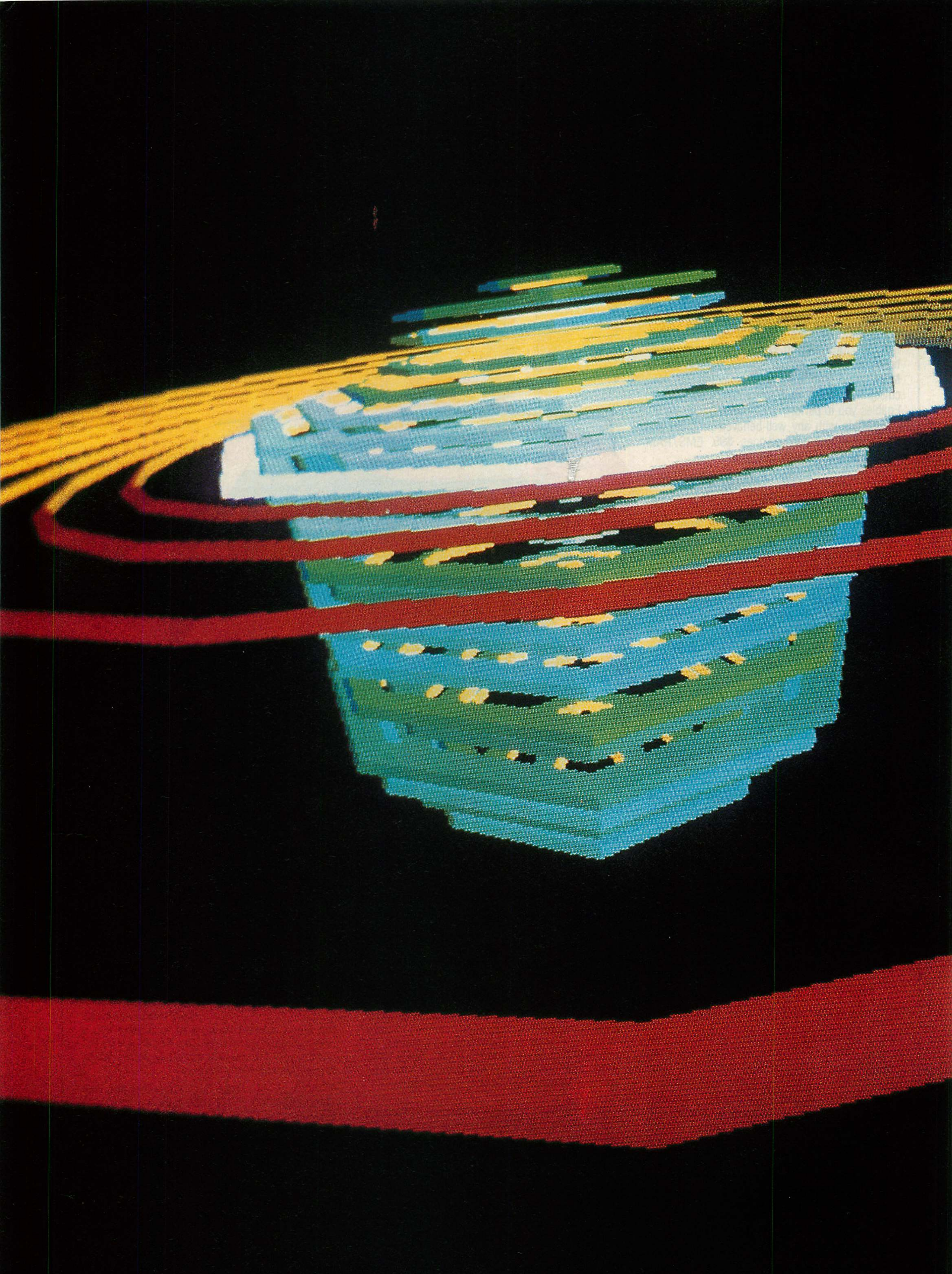
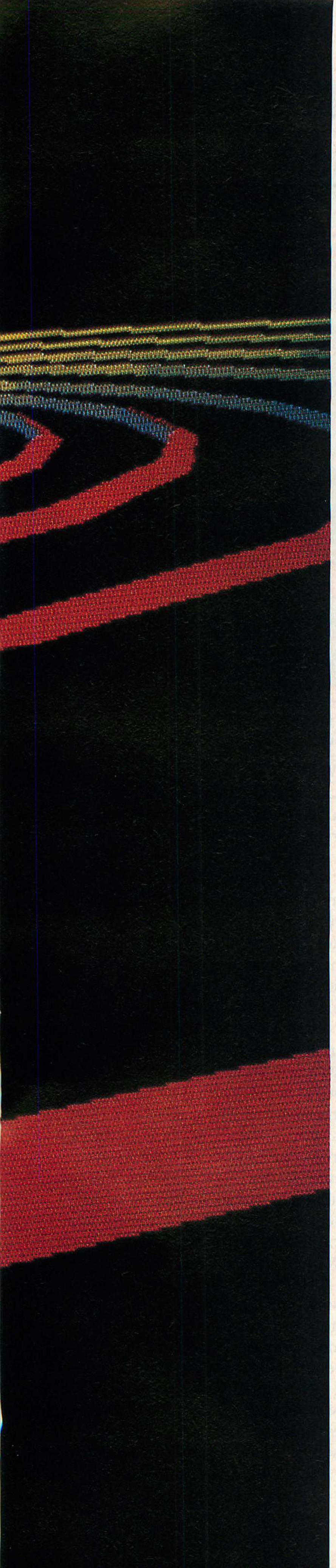


REALTIME SYSTEMS



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A Message-Passing Executive

Although it is a realtime operating system first, QNX derives its real strength from its ability to infuse realtime executive power and control into networking situations.

GARY ELFRING

The development of software usually involves a number of trade-offs during design. Each product ultimately reflects the elements its designer considers to be most important (or perhaps most marketable). Realtime executives, for example, typically are designed to deliver blazing speed. Finding the best executive for an application generally involves evaluating the optimal combination of speed and price—with disk/file control and networking ability often taking a back seat. The problem with this approach is that speed is not always the sole, or even the best, criterion for selecting a realtime operating system.

The major task of any realtime executive always has been to monitor a number of input signals and to produce some output based on those inputs within a limited amount of time. As computers become faster and less expensive, the number of features available (and indeed often demanded by users) in a typical executive has increased dramatically. It now has become feasible to build realtime control systems that require networks of PCs operating concurrently.

Imagine, for example, a factory that produces a cornflakes cereal. The various ingredients that go into the cornflakes must be mixed, then baked in an

oven. This mixing-and-baking process would be under the control of one PC. The PC also must control the furnace temperature for baking. Once baked, the cornflakes must be put into boxes. A second PC would monitor and perform limited control functions on a group of filling machines. Finally, all the cornflakes boxes must be weighed. A series of check-weighing machines would operate under the control of a third PC. These devices would reject cereal boxes that are too light. The PC monitors the operation of the check weighing machines, but it does not actually control them.

Each of these three PCs must perform several different realtime control functions. The tasks are sufficiently complex that to integrate all functions into just one PC would be impossible. However, information from each control system must be available to the other two PCs. Some type of operator alarm system also must be provided that would alert maintenance personnel to problems with cereal box weight. (If cornflakes boxes are consistently too heavy or too light, the problem may be with the filling machine, or it may involve the cornflakes themselves. In that case, adjustment would have to be made to the baking process.)

Designing a networked realtime system to perform these functions presents some difficulties. The first requirement is a realtime database. This database must supply a form of record-locking to keep separate operators or machines from simultaneously changing the same piece of information. Then, the system needs all three computers to operate in realtime, yet to remain simultaneously linked or synchronized. The executive that is chosen must be able to initialize the entire system at once and to pass messages from a task in one machine to a task in another. In addition, tasks running in one machine should be able to exert some control over tasks in the other two; thus, the tasks in each machine must interact with each other in realtime.

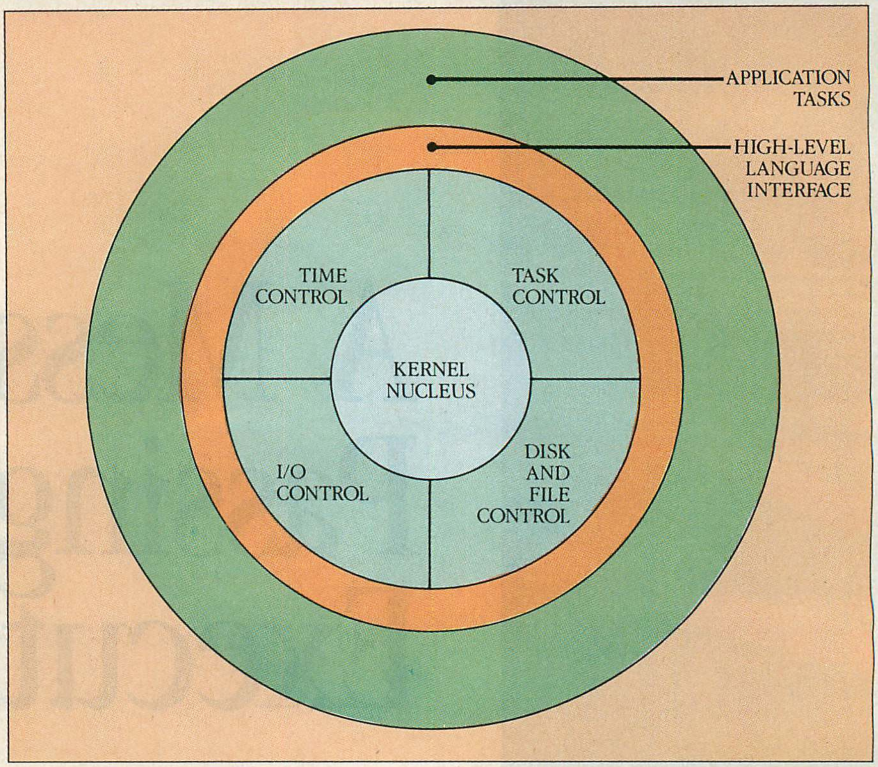
QNX, a realtime operating system from Quantum Software Systems Ltd., is designed to handle just this kind of situation. QNX provides a multiuser, multitasking, multiprocessor, realtime environment for the development and execution of an application. Reviewed here specifically are QNX versions 1.2 (standalone) and 2.0 (networked).

QNX runs on the PC, PC/XT, PC/AT, and compatibles. Most standard PC devices are supported, including the IBM Enhanced Graphics Adapter and Enhanced Color Display. The operating system requires approximately 100KB of memory to load and bring up a shell; a minimum of 192KB is needed for a single-user system. Running commands in the background or support of additional users requires 256KB or more.

Although QNX is not DOS-compatible in file structure or system call format, a program is available that lets the user read and write DOS files; another program runs DOS as a task on the AT. When running on an AT or compatible, QNX can operate in either the real or the protected mode of the 80286. When in protected mode, however, as much as 15MB of memory may be used. In this mode, DOS emulation is supported only for the IBM AT and the Compaq Deskpro 286.

QNX provides a rich UNIX-like operating environment for developing realtime application programs. Yet, it is not another version of UNIX and, in fact, contains no AT&T code. QNX is designed to handle realtime applications. It offers a true message-passing architecture with full network support.

FIGURE 1: *Typical Realtime Executive Structure*



Most realtime executives can be visualized as a kernel surrounded by various system managers. An application code task then surrounds this nucleus.

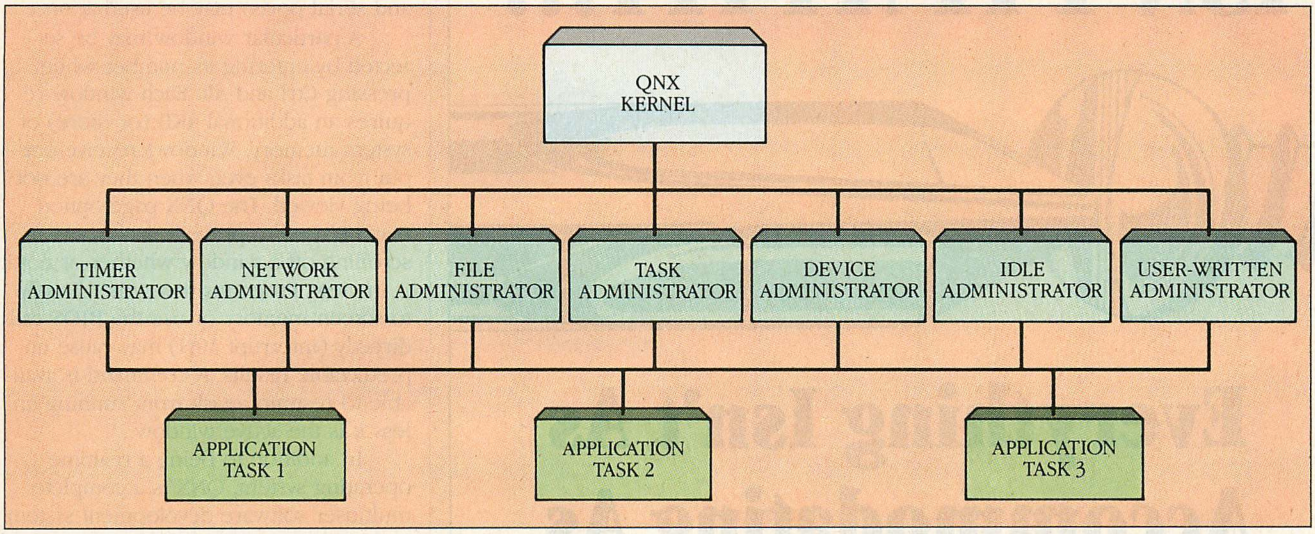
STRUCTURAL DIVERGENCE

The internal structure of QNX is significantly different from that found in many realtime executives. Most others can be visualized as a circular kernel surrounded by various system-level managers; application tasks then surround this nucleus, as shown in figure 1.

QNX does use a small kernel for its most basic operations, but the similarity to other executives ends there. Under QNX, most hardware management and, indeed, a great many of the executive's realtime functions, are performed by *system administrators*, which are simply tasks running under the operating system kernel that provide specific operating system functions; most are supplied by tasks that can be augmented easily by user-written tasks. This approach does not require the source code to QNX to make major changes in the way it operates. This can be advantageous in attempting to customize an executive for a specific application. Figure 2 is a diagram of the QNX system architecture.

QNX was designed as a message-passing operating system. Unlike most realtime executives, which pass pointers to messages between tasks, QNX passes the entire message from task to task. The QNX approach is considerably slower than the other, but it has advantages. Because entire messages are passed, it does not matter to the executive if the tasks reside in the same or a

FIGURE 2: *QNX Realtime Executive Structure*



QNX has a small kernel for its most basic operations. System administrator tasks perform specific operating system functions.

different machine. Thus, true networked realtime control becomes possible. A task that wants to pass a message to another task does not need to know in which system that task resides; networked communications are relatively transparent to individual tasks.

However, this architecture has a serious impact on the speed with which the QNX operating system can run. On a 6-MHz AT running in real mode, QNX can schedule a task to run in about 476 microseconds; in protected mode, this operation takes 612 microseconds. Although this may seem reasonably quick, it tells only half the story. All realtime systems must perform some kind of intertask communications. But in a full message-passing environment, these communications are inherently and considerably slower than in executives, which do not pass entire messages.

The QNX operating system comprises two major elements. The basic kernel provides a fixed minimum set of services, including message forwarding, clock interrupt handling, and virtual circuit management. All other features of the system are under the control of standard administrators. Additional administrators may be added as needed.

The task administrator (task ID 0001) is responsible for all basic task control functions, including creating or destroying tasks. If a task needs information about another task, it can interrogate the task administrator to obtain the other task's current status. The task administrator also performs some memory management functions.

The file administrator (task ID 0002) controls all access to and from the QNX drives, including diskette, hard, and RAM disk. The basic file structure and access methods are defined by this administrator. The QNX-supplied administrator provides a tree-structured method of disk access very similar to, but not compatible with, that supplied by DOS or UNIX. Like DOS and UNIX, QNX supports a simple method of file sharing that is adequate for many applications. It will not, however, be adequate in situations where concurrent tasks must read *and* write from disk files. For this situation, the user will need to write a new administrator.

The responsibility for control of all serial devices in a system falls with the device administrator (task ID 0003). Typical serial devices include terminals, modems, and printers. The actual drivers needed to access the serial ports are contained in this administrator. These drivers typically provide all device-specific control functions; for example, all code for an XON/XOFF protocol would reside here. Thus, the serial device administrator isolates tasks from most aspects of device control.

Accounting for all idle time in the system is the idle administrator (task ID 0004), which is also the default owner of all child tasks that must run after the death of a parent task. (Some portion of program code must be running at all times; an idle administrator serves to soak up all free time.)

The network administrator (task ID 0005) controls all access to and through the QNX network. Its use is optional because QNX does not require a network to run. This administrator manages all the network aspects of virtual circuit control and message passing (explained below); it also can boot other machines (or *nodes*) onto the network by passing a start-up code to them. (QNX nodes are networked using an implementation of Datapoint's ARCNET. The network uses a token-passing scheme and operates at 2.5 megabits per second. A QNX networking board is required for each node, and stations are connected using RG62U coaxial cable. A passive hub can be used to connect up to four stations; an active hub is required for larger configurations.)

The timer administrator (no fixed task ID) is responsible for all task-related timing functions. It provides time control and alarm functions for tasks requesting such operations. Use of the administrator is optional.

Typically, an administrator task is written as a loop that first receives a message. The ensuing code generates a specific action for each possible message case that the administrator might receive. The loop ends when the administrator replies to the message. User-written administrators never use the SEND function because this would keep the administrator from operating, pending a reply. All administrators should run at a higher priority than any task that uses that administrator.

A FERTILE ENVIRONMENT

QNX can support several full-screen windows on the PC display. Windows may be assigned to different tasks or to the same task. One window is available when the system's initial program is loaded; others may be opened using the MOUNT command. A maximum of

13 windows and standard devices (including the PC display, line printers, and serial ports) may be used at once.

A particular window may be selected by entering its number while pressing Ctrl and Alt. Each window requires an additional 4KB (or more) of system memory. Windows receive output from tasks even when they are not being viewed. The QNX page option may be used to prevent data from scrolling off a window whether or not it is in view. Programs that write directly to screen memory or use the BIOS calls directly (interrupt 10H) may cause unpredictable results. A command is available to restrain a task from running unless it is the active window.

In addition to being a realtime operating system, QNX is a complete multiuser software development system. It supports as many as 11 users on each PC; one user may access QNX through the PC while the others use terminals. Most QNX utilities and applications are designed to be device-independent and thus do not require the PC display to perform. Because QNX supports high-speed networks of PCs, very large networks can be developed to support hundreds of users.

System security is provided in this system with PASSON, a command that restricts access to designated files to individuals with a valid user ID and password. A programmer can define a list of valid users for a given application, thus possibly eliminating the need for security routines. This type of security often is necessary to both multiuser systems and realtime applications.

QNX offers a variety of specialized utilities. A RAM-disk driver is available, as are an electronic mail system (MAIL) and an appointment scheduler (AP). All QNX utilities work on either individual or networked systems.

The system combines two different approaches to produce one uniform environment. QNX is a true realtime operating system; at the same time the QNX file system is UNIX-like, offering full tree-structured directories, similar file-naming conventions, data security, and a program development environment that resembles UNIX closely. (As noted, the QNX operating system and files are neither DOS- nor UNIX-compatible.)

QNX boasts a rich variety of commands, the majority of which, in spite of their not being compatible, are similar in format to their UNIX counterparts. Commands are available to: list and dump directories and files, edit files, manipulate directories and files, move files, execute disk utilities, handle

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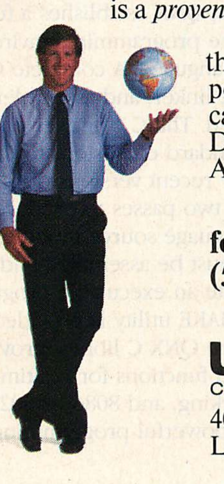

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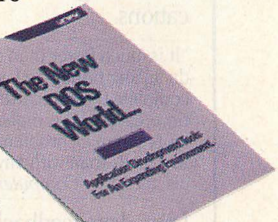

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TABLE 1: *QNX System Commands*

FILE and DIRECTORY MANIPULATION	**FILE and DISK UTILITIES**	**QNX UTILITIES**	**INFORMATION HANDLING**	**NETWORK UTILITIES**
cd	arch	apb	crypt	alive
chattr	backup	beep	diff	kill_vcs
drel	cat	break	locate	poll
dump	chkfsys	cron	msort	
eo	copy	date	pack	**EDITING and WORD PROCESSING**
expl	cp	kill	size	
files	dinit	mount	wort	
frel	dcheck	nacc	wc	ed
list	dcopy	net	xlat	led
ls	ddump	passon		
mkdir	fdisk	search		**COMMUNICATIONS**
p	fdformat	slice		comm
patch	query	spool		stty
pwd	spatch	task		talk
rm	split	tcap		
rmdir		who		
ws				
zap				

Although QNX is not a UNIX system, many of QNX's large assortment of commands are similar in format and function to corresponding UNIX commands.

information, use the QNX network, communicate over modems, and perform various tasks specific to the QNX environment. Table 1 lists the major QNX operating system commands.

The QNX utilities with standard UNIX counterparts include **cd** (change the current directory), **ls** (list a directory), **mkdir** (make a new directory), and **rm** (remove a directory). QNX offers two different text editors: **ed** is a full-screen editor, **led** a line-oriented editor. Two other programs, **arch** and **backup**, perform the archiving of programs to diskette or tape or back up to diskette, respectively. **Crypt** provides encryption/decryption functions for sensitive files, and, finally, **comm** and **talk** permit communications over modems and to mainframes, respectively.

In addition to operating system utilities, QNX establishes a full-featured realtime programming environment for the C language. A complete C compiler, library, linker, and assembler come standard. The C compiler offers most of the standard extensions to C made popular by recent versions of UNIX; it requires two passes to produce an assembly language source module, which then must be assembled and linked to generate an executable program. A standard MAKE utility is provided.

The QNX C library provides specialized functions for realtime control, networking, and 8086 or 80286 support. It is a powerful programming tool. The library is *shared*, in that only one copy of the standard library is resident in QNX at any one time. C programs do not include a copy of the library functions that they use (DOS-developed programs, for example, do).

The shared library is a function module that is loaded into program memory using MOUNT. Once a library is mounted, it remains resident in QNX until the system is rebooted. As long as a shared library is mounted, any task can access the functions in the library through a software interrupt. This technique keeps program size to a minimum, thus saving precious memory.

Under QNX, programmers may create their own libraries for program tasks. In general, QNX shared libraries must be reentrant. In C, this means that global variables or any static variables to which functions write cannot be used; static variables may be used in a read-only manner. Essentially, the goal is for all local data storage for the function to come from the stack. In compiling the modules for a shared library, the stack-checking code option of the compiler should be turned off. The shared library also must be patched, using the PATCH command, to change its type. A shared library usually contains only executable functions. Occasionally, it may contain a data table, but such a table must never be written to because record-locking features are not available in shared libraries.

Besides C, QNX supports compiled BASIC, FORTRAN, and Pascal (as optional components at additional cost). All object modules follow the same format so that modules compiled from different languages may be mixed, provided attention is paid to the way in which arguments are passed.

TASKS AND SCHEDULING

Under QNX, a task is simply a small program designed to accomplish a single objective. As is the case with most realtime executives, QNX makes it appear as though a number of different program tasks are running concurrently on a PC. The operating system accomplishes this by switching very quickly among separate tasks. QNX defines the relationship among tasks running under it as follows: a parent task is an original task started from a terminal; a child task is created by a parent. In general, when a parent task dies or is terminated, all of its child tasks also are terminated.

Tasks that are not blocked will be run on the basis of an associated priority assigned to each QNX task. Task priority can range from 1 (the highest) to 15. In the off-the-shelf QNX package, priority 1 is reserved for the task administrator, and priorities 2 and 3 are reserved for other QNX administrators. Thus, the highest priority that can be assigned to a user task is 4. User tasks must not compete with the QNX administrator task for processor time.

Any task may create child tasks. One of three relationships will result, depending upon the assigned priority. If a task creates a child task of higher priority, the child runs to completion before control is returned to the parent (the parent task is suspended until the child task completes). This feature is used chiefly in special situations. For example, a communications task might detect an important message that must be answered before any further actions can be taken. A high-priority child task could be created that would answer the message, then return control to its parent. If a child process *is created with* the same priority as the parent, the two execute concurrently. Finally, a parent may create a child task of lower priority that executes when the parent becomes blocked for any reason. A child process (of lower priority) also may be created that continues to run even after the parent dies. Such a child process might perform some form of clean-up of hardware or software functions.

In connection with the QNX support of a realtime networked system, tasks refer to other tasks running on different nodes as *virtual tasks*. A virtual task runs concurrently with all tasks in other nodes. (Because the tasks reside in different machines, they actually do execute in parallel and simultaneously.) Any task can create a child process on another node by communicating over the network to the task administrator of the other node. The status of the child process depends upon the current status of the virtual tasks resident in that node. Tasks running on different nodes can communicate with each other.

QNX provides three separate task creation functions (as part of its C library): CREATE, FORK, and SHELL. The CREATE function lets the user construct a new task on any node in the QNX system. Along with the priority assignment for the new task, an optional list of arguments may be passed to the task when it is started. FORK creates an exact duplicate of the current task (the new task is the child of the task that issues the FORK command). Both tasks share the same priority and code segment, but not the same data segment. Finally, SHELL creates a new task by

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parsing a passed string, an action equivalent to entering a command into the operating system shell. Thus, a task can invoke system commands as if they were entered from a terminal.

Task scheduling is handled differently under QNX than under most realtime executives. QNX follows a preemptive, time-sliced, priority-based method in which task preemption takes place instantaneously rather than at the end of a clock tick. For example, when a task of higher priority is scheduled, the very act of scheduling the higher task causes it to be run immediately before control is returned to the parent. Tasks of the same priority run in a time-sliced arrangement: the number of clock ticks allowed for each task can be set using SET_SLICE. Control among tasks of the same priority is handled on a round-robin basis; however, tasks are always executed in the same order in which they were originally scheduled.

This time-sliced scheduling of tasks gives QNX an important advantage in the construction of realtime systems. Without it, a single time-intensive task can degrade an entire system's performance. Time slicing can serve other important purposes as well. It can be used to distribute computer processing time more evenly among several tasks performing similar time-consuming functions. This makes the operation of the entire group of tasks appear more even. If a task becomes I/O-bound or takes too long to execute, QNX suspends its execution and switches to the next task of like priority. All tasks of a given priority are completed before tasks scheduled at the next lower priority are run.

The QNX architecture supports as many as 256 different tasks, yet the standard QNX system allows the user to create a maximum of only 40 tasks at once. Another QNX version (for the AT and compatibles) permits 64 tasks.

The status of any task running under QNX can be investigated at any time using the TASK_INFO function. This function returns the full status, including such items as task priority, blocked state, links to other tasks, message status, and memory requirements. TASK_INFO works on virtual tasks through the network.

Tasks under QNX also have an associated state. A task can be *ready*, which means it is ready to run based on priority and time-slicing constraints. A task also can be *dead*, which implies that the task has completed its execution. In addition, a task can be *held* by other tasks, or it may be *blocked* for some reason. Blocking usually takes place with a task that is trying to send, receive, or reply to a message. If a task attempts to send a message to another task that is not ready, the sending task will block. This blocking can occur locally or over the network.

Finally, tasks can exert control over each other using two specialized functions: HOLD gives one task complete control over another task (and all of its child tasks) or can be used by a task to stop itself or another task; UNHOLD removes previous hold actions on a task. Both functions work on virtual tasks.

INTERTASK COMMUNICATION

QNX provides three methods of intertask communications: *ports* (not to be confused with serial or RS-232 ports), *message passing*, and *exceptions*. Each method offers its own speed and information-carrying abilities. Quantum also has recently implemented *mailboxes*, which allow a task to check for and read stored messages without blocking. Mailboxes will become an integral part of all future QNX releases. Collectively, these tools provide a complete array of realtime communications tools.

Ports. This method provides the simplest communications between tasks. A port is simply a binary number from 0 to 255 that is reserved to describe a user-defined operation. Ports usually are associated with external hardware events and are used to synchronize a task with that hardware or another task. Ports are employed as semaphores to control access to hardware or a specific resource. When two tasks communicate through a port, no actual message is passed between them. Only an event, or the lack of one, is signaled. Although QNX has the capacity for as many as 255 ports, it is typically configured with only 28 or 40. Information on how the QNX package is configured is not included in the documentation.

To use this method, a task first invokes the ATTACH function to lock onto a specific port (by number). Once attached, that task owns the port until it executes a DETACH function. A second task attempting to attach to the same port will fail. That task can use DETACH to determine the task ID of the task that owns the port. The second task then can wait until the task that owns the port either detaches or dies (which automatically detaches the port). This method can be used to synchronize any number of tasks. It provides a simple semaphore to control the access of multiple tasks to a common resource.

Several other functions provide more advanced port-related utilities. A task can wait for a signal to be sent to a specific port using AWAIT. The task will remain blocked after it has performed the AWAIT until a signal is sent to that port via either a SIGNAL or a CSIGNAL function. READ_PORT allows a task to detect whether any signals are pending on a port, without suspending the task's operation if no message is there.

Ports are the primary method used by interrupt handlers to communicate with other tasks under QNX. Port-related functions execute quickly because they do not pass messages. Ports are also a convenient way to synchronize independent tasks. A listing routine, for example, might attach to a specific port. This would signify that the printer is currently busy. Any other task that wishes to use the printer would first attach to the specific port to see if the printer were available. If the ATTACH is not successful, the task would have to wait for the task that is attached to the port to DETACH. When the listing task detaches, the printer is free, and other tasks then can use it by attaching themselves to the specific port. This effectively builds up a queue of tasks, all of which want access to the printer. These tasks execute one at a time in the order they were scheduled.

Messages. A message is a sequence of bytes (between 0 and 65,535 in length) that is passed from one task to another. No format is assumed or imposed on the content of the message by the operating system; each task or application must impose its own structure on the contents. The message-passing protocol is determined by the application task. In a typical protocol, one task will block, awaiting a message. When a second task sends a message to the blocked task, the blocked task will activate, process the message, and send a reply.

Passing messages is an inherently slow method for a realtime executive, and the time it requires depends on the length of the message passed. This restriction may cause problems for high-speed operations.

QNX offers special function calls that allow tasks operating on different network machines to communicate with each other. The functions VC_CREATE and VC_RELEASE let tasks control the operation of a *virtual circuit*, which connects two virtual tasks with a private data channel. No task ever has to send a message explicitly across the network—it simply opens a virtual circuit. This is done by first executing VC_CREATE, which returns a virtual task ID. From that point on, operation of the virtual circuit is transparent to both tasks. When the virtual circuit is no longer needed, the sending task must release it back to the operating system using the function VC_RELEASE.

Messages may be passed between tasks using any of several different methods. One of the simpler techniques uses the three functions SEND, RECEIVE, and REPLY. These functions allow a task to send a message to another task and wait for a reply. Messages under QNX are never lost, as can happen with some other realtime executives. If a message is sent to a task that is not ready for it, the message is saved until the specified task is ready to accept it. The sending task is blocked until it receives a reply to its message. Note that this method of message passing has repercussions for both sending and receiving tasks.

The operation proceeds as follows: SEND passes a message to a specified task and allocates room for a reply from the receiving task; the sending task then blocks until the second task receives the message and sends a reply. The function RECEIVE performs the other half of this operation. A task that exe-

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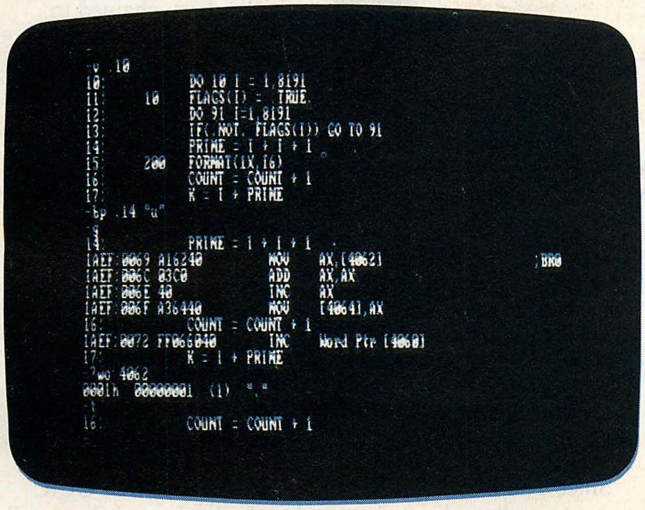

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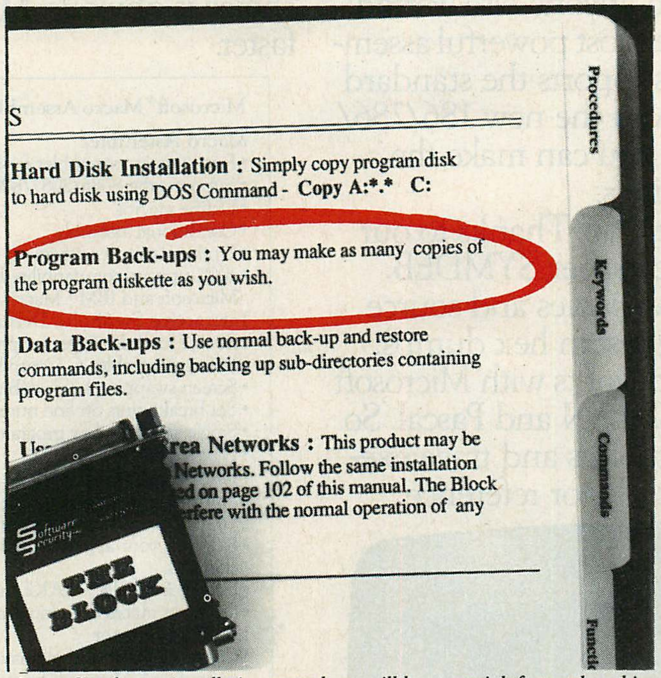

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TABLE 2: *QNX System Exceptions*

EXCEPTION	DEFINITION
EXC_HANGUP	Loss of modem carrier
EXC_BREAK	Keyboard break
EXC_QUIT	Program debugging
EXC_COM	Communications error
EXC_SHARE	Missing shared library
EXC_FLOAT	Floating-point error
EXC_KILL	Kill task
EXC_MEM_V	Memory violation
EXC_ALARM	Set by system timer task
EXC_TERM	Task termination
EXC_DIV_Z	Divide by zero

QNX supports 32 exceptions that are used to notify a program of specific circumstances or events. Currently, 11 system exceptions are defined.

cutes a RECEIVE will block until a message has been received. (If a message has already been sent to this task before it performed the RECEIVE, the task does not block, but instead immediately processes the message that was sent to it.) Once the receiving task has processed the message, REPLY is used to send a reply back to the sender. It can be used only after a RECEIVE command and causes a specific response to be sent to the appropriate task. No task blocking occurs on the receiving end.

Sometimes a task needs to be able to read in a message without blocking if no message is waiting for it. (The task does not want to remain blocked, waiting for a message that might never arrive.) In this case, CRECEIVE, a non-blocking form of RECEIVE, is used. When a task executes a CRECEIVE, it returns either with a message, if one was pending, or with an error condition, indicating that no message was found.

Another useful message-handling function, RELAY, allows a task to relay, or pass on, a message to another task. This function does not block either task. RELAY allows a task to send the same message to more than one other task.

Exceptions. This method passes limited messages between tasks. Exceptions are used for specific circumstances or special events associated with program tasks. An exception can be generated as the result of a hardware or software problem and is task-specific with regard to the tasks it addresses. For example, an exception generated for "loss of modem carrier" has no effect on tasks not concerned with the modem.

QNX supports two types of exceptions: system or user-defined. Within each type, 16 different exceptions are possible. The 11 currently defined system exceptions are listed in table 2.

Two functions are involved in the generation and handling of exceptions: SET_EXCEPTION and EXC_HANDLER. If an exception is generated for a specific task, and no exception handler has previously been established by that task, then the task in question is destroyed. (This task destruction includes all child tasks.) SET_EXCEPTION lets a task generate a specific exception, either system or user-defined, for a task. The function EXC_HANDLER lets the task define a handler for a specific exception. Once an exception handler is defined, exceptions signal the occurrence of an unusual event. The software exception handler then responds to the event.

Mailboxes. A realtime system often requires more communications capability than is available with the simple message-passing functions just described. For example, a task might have to wait for a message or for a fixed time to expire. Further, it might have to wait for a message from one or more possible sources. Functions such as these typically are accomplished in realtime systems via mailboxes. The QNX mailboxes are supplied in source code form and are arranged as administrator tasks. The user thus can extend the mailbox concept or alter its operation if desired.

The mailbox administrator supplied by Quantum contains seven major functions. (In addition, provisions have been made for extending the mailbox concept to include waiting on multiple mailboxes, optional time-outs associated with a mailbox, and the use of signals or ports to trigger mailboxes.)

MBOX_OPEN and MBOX_CLOSE enable a task to create and use a mailbox. When a task attempts to open a specific mailbox, the administrator first checks to see if such a mailbox already exists. If it does, MBOX_OPEN returns

status information about the mailbox. If the mailbox does not exist, the administrator creates a new one. The function MBOX_CLOSE terminates a specific mailbox; it can be altered to ensure that the mailbox would be terminated immediately or following the reception of all currently pending messages.

MBOX_WAIT lets a program block pending mail at a specific box. Optional extensions to this function would let a task wait, pending receipt of a message at any of several different mailboxes or for a specific period.

Three interrelated functions are used to control the sending and receiving of messages at mailboxes. The function MBOX_POST sends a message to a specific mailbox. MBOX_QUERY lets a task check for mail without blocking. MBOX_READ allows the task to read any mail that is found. All three functions require the mailbox in use to have been opened previously.

Finally, MBOX_INFO is a debugging tool that provides a "snapshot" of the mailbox system at any time. It can report the status of all mailboxes, tasks, and messages running under the mailbox administrator. The documentation offers only a skeleton outline for this function. Because it is primarily a debugging tool, the exact nature of its operation is determined by the specific application being debugged.

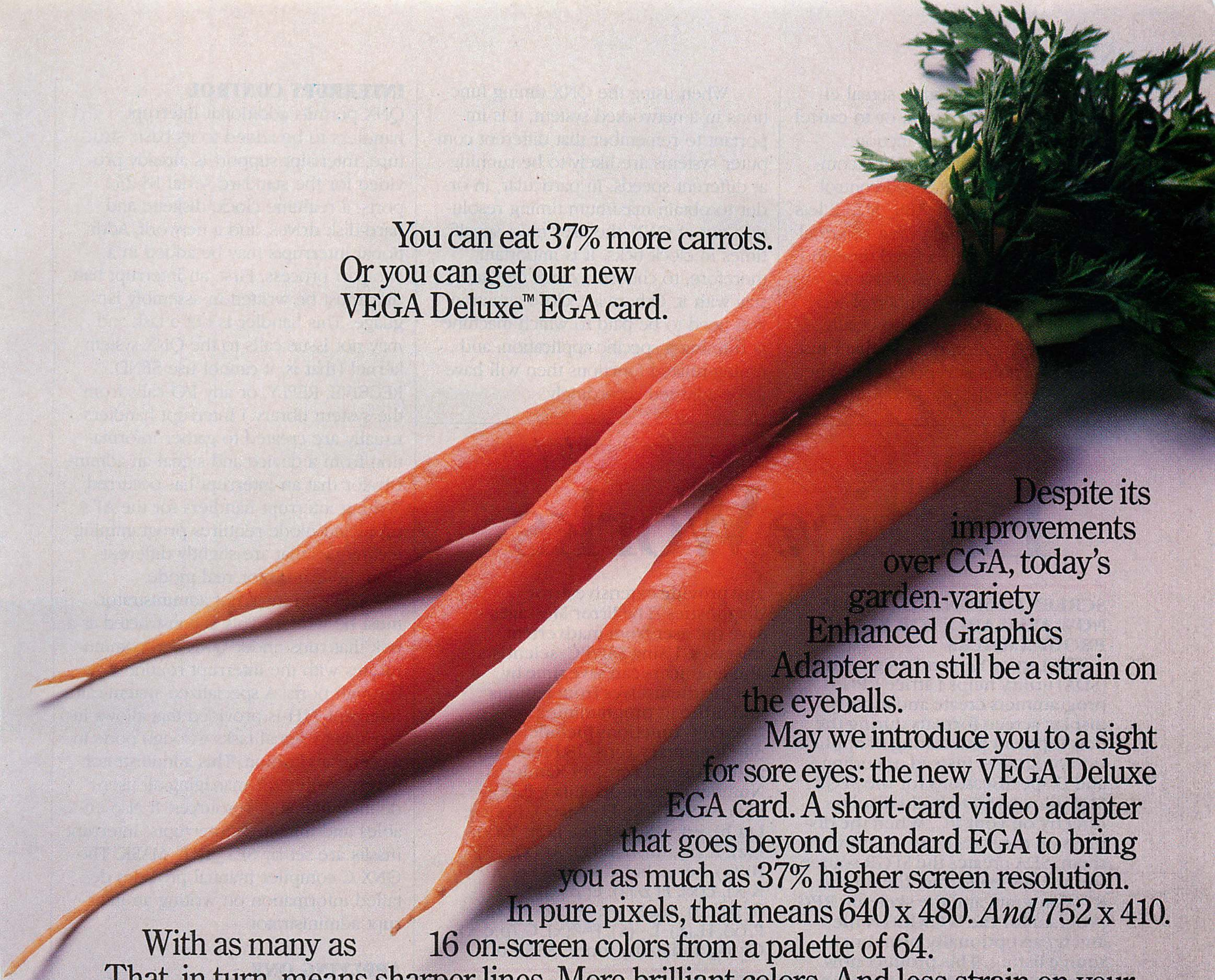
MANIPULATING TIME

A good realtime executive offers various means to control tasks based on time or to time assorted program functions. QNX has two types of time-control function. The first set—which consists of GET_DATE, GET_TICKS, SET_DATE, and SET_SLICE—controls the operating system's use of time. The second set—ABS_SLEEP, SET_TIMER, and SLEEP—is used to control tasks or program operation based on time.

GET_DATE and SET_DATE get or set the current system time and date. Each is accurate only to the nearest second. Finer accuracy is provided by GET_TICKS, which returns a value representing the current number of system clock ticks. This number is not directly related to any particular time. The standard QNX system uses a default clock rate of 20 ticks per second, allowing GET_TICKS to measure time to within 50 ms. The default tick of 50 ms often is not fast enough for realtime functions that require time control. Therefore, a special function called CHANGE_TICK lets a task change the number of ticks per second. Quantum says that the tick rate may be set as high as 250 ticks per second for a PC or 1,000 ticks per second for an AT. Such high rates significantly increase system overhead.

SET_SLICE defines the number of clock ticks represented in each time slice. This function is used to determine the amount of time every program task is allotted as it is time-sliced by the operating system. CHANGE_TICK interacts with the function SET_SLICE because time slicing is defined in clock ticks, not in fractions of a second.

QNX supports a variety of timer actions. All timing functions use a single call to the SET_TIMER routine. This call must specify either a relative amount of time measured in clock ticks or a fixed time and date. (Note again that specifying time in clock ticks provides for a finer control over realtime tasks.) When a time has expired, several control options are available. For example, the timer call can be used to block the current task until the time has expired. A timer call also can be used to force a task to become ready that previously had been blocked because of a SEND, RECEIVE, or REPLY. The SET_TIMER



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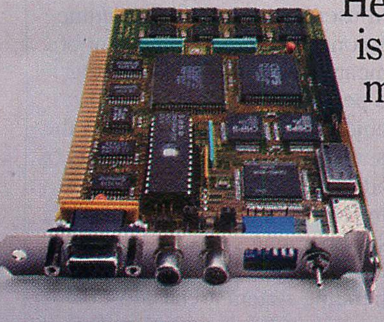

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routine also can be used to signal either a port or an exception or to cancel any previously set timer function.

The ABS_SLEEP and SLEEP commands give a task time-based control over its own execution. ABS_SLEEP lets a task suspend operation (that is, actually to block itself) until a fixed time and date transpires. SLEEP lets a task suspend itself for a fixed number of seconds. Both commands are especially useful in the creation of tasks that must perform functions at repetitive or other fixed-time intervals.

When using the QNX timing functions in a networked system, it is important to remember that different computer systems are likely to be running at different speeds. In particular, in order to obtain maximum timing resolution out of QNX, the user must specify times in clock ticks. It is important, therefore, to choose a clock rate and stay with it. Otherwise, close attention will need to be paid to which machine is running a specific application, and timing-related functions then will have to be adjusted accordingly.

INTERRUPT CONTROL

QNX permits additional interrupt handlers to be added to its basic structure. Interrupt support is already provided for the standard serial RS-232 ports, a realtime clock, diskette and hard-disk drives, and a network. Additional interrupts may be added in a two-part process. First, an interrupt handler must be written in assembly language. This handler is not a task and may not issue calls to the QNX system kernel (that is, it cannot use SEND, RECEIVE, REPLY, or any I/O calls from the system library.) Interrupt handlers usually are created to gather information from a device and signal an administrator that an interrupt has occurred. Writing interrupt handlers for the AT's protected mode requires programming techniques that are slightly different than those used for real mode.

Next, an interrupt administrator must be written. This is constructed as a task that runs under QNX and communicates with the interrupt routine through ports. A specialized system-call interrupt 71H is provided that allows interrupts to signal tasks through ports in a reentrant fashion. This administrator is responsible for managing all user-defined interrupt resources. It also enables and initializes interrupts. Interrupt masks are set by SET_INT_MASK. The QNX C compiler manual provides detailed information on writing an interrupt administrator.

APPLYING QNX

QNX is not a dominant realtime control system for the IBM PC. Although it is a popular operating system, 50 percent of its users do not take advantage of its realtime control features. According to Quantum, only about 20 percent of the installed user base exploits its realtime process control. Another 30 percent of the company's customer base is using QNX to perform point-of-sale and data communications applications that, in the process, make use of realtime aspects of the product. The remainder of QNX users are employing it as a multitasking, multiuser operating system.

QNX is not well known in the realtime operating system arena. Most of the dominant realtime executives for the PC can trace their roots to other computer systems. Hunter & Ready's VRTX/86 and Intel's iRMX86, for example, both existed long before the PC was introduced. Each of these executives had a large base of users when the system was ported to the PC. Newer executives either have had to take users away from the market base of others or

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have had to impress prospective buyers with the merits of a newer system.

Another reason for QNX's anonymity is its slant toward networked realtime control and emphasis on a multiuser approach. Most programmers doing realtime control work are more experienced in building single, dedicated, nondisk-based control systems. Realtime applications that require networking or multiuser input have become prominent only in recent years.

One significant problem with QNX is its documentation. Although it is lengthy (more than 1,000 pages), it is not oriented toward realtime control and does not even have a section or chapter devoted to realtime applications. In addition, many important details about the QNX realtime operation are not discussed; for example, no mention is made of the execution times needed to complete any of the realtime functions described in this article.

QNX's documentation, like that for many microcomputer products, is simply not at the same level as the software. In an effort to provide up-to-date information to users, Quantum does maintain an on-line system to all licensees that provides updates, material on known QNX difficulties, and so on.

QNX is also considerably slower than most of the other realtime executives previously reviewed in this *PC Tech Journal* series. The standard QNX clock tick on an AT running at 8 MHz is 50 ms (by contrast, several realtime executives are available for a 2-MHz 8080 that offer 1- or 2-ms clock ticks.) The QNX clock period is not fast enough to monitor transient events. Even though the period can be made shorter, the attendant increase in system overhead makes it difficult for QNX to compete with more tightly coded realtime executives. Using QNX to perform a large number of hardware control functions in realtime would be impractical.

Finally, QNX passes entire messages between tasks. Although this architecture allows QNX to take full advantage of its network configuration, it slows down the realtime operation of the system (because the length of the message directly impacts the time it takes to pass it). In addition, the majority of QNX realtime control functions cannot be used in interrupt handlers because they take too long to execute.

In what way, then, can QNX be used? In networking situations. The QNX system excels at networked realtime control that involves databases. It is currently being used successfully in numerous automated assembly line situ-

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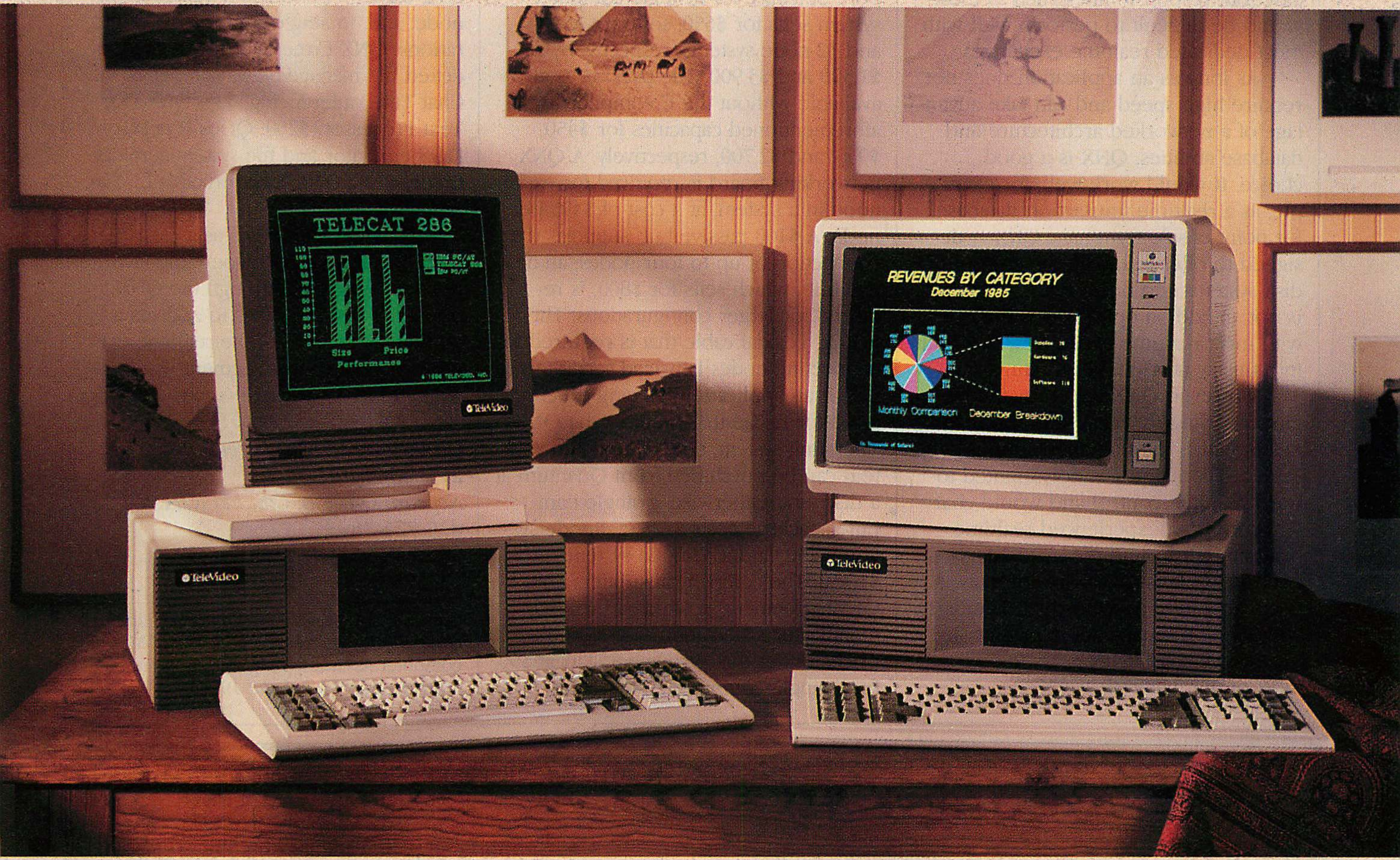

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ations. The cornflakes control system described at the beginning of this article requires three PCs that share access to a common base of information about the cornflakes manufacturing process. QNX could manage this system with ease, but responsibilities such as these would be difficult to perform well with most dedicated realtime executives.

As long as an application does not require high speed and can take advantage of a networked architecture and database abilities, QNX is a good choice. It would work well, for example, as a realtime transaction database for point-of-sale terminals. QNX is designed to offer full, realtime control of disk systems and networks. This ability is not an add-on option, as is the case with most realtime executives; it is built into this system's basic structure.

However, QNX is not for the beginner, primarily because of the manner in which the documentation is presented. The manual is not oriented toward realtime control and would challenge even an experienced realtime programmer to find the material needed to explain QNX realtime aspects. In addition, a thorough familiarity with the C language and a passing acquaintance with UNIX is assumed by most of the material.

OTHER PRICES PAID

The basic QNX development system includes the kernel, full-screen editor, utilities, C compiler, and manual. The price of this package depends upon the number of nodes it is intended to support. Software for a single computer system sells for $650; software for 4- and 32-node systems, respectively, is $1,300 and $3,900. The package is also available without the C compiler in the aforementioned capacities for $450, $900, and $2,700, respectively. A QNX networking board is required for each node in a system, at a cost of $495 per node. A $100 passive hub supports the connection of up to four nodes; an active hub, which sells for $800, is required for larger configurations. The RG62U coaxial cable that is required for connecting nodes is priced separately.

If an application is being developed for resale that requires the QNX operating system, the QNX runtime system can be purchased from Quantum at a discount. Otherwise, a single computer package costs $225, a 4-node system, $450, and a 32-node system, $1,350. The company also offers an OEM agreement in which a firm may manufacture the runtime system; the prices under this agreement start at $90 for a single computer system, plus $22.50 for each additional node. Substantial discounts also are available on large-quantity purchases.

Several optional items for the QNX operating system include: a BASIC compiler for $300 in single-node configuration, $600 in 4-node, and $1,800 in 32-node; and, in single-computer configurations: QNX Ctree, which provides indexed file management, $295; QNX Chat Teleconferencing, $95; QNX Doc Text Processor, $250; QDos II, a PC-DOS emulator and file system administrator, $125; QNX Electronic Mail, $150; and QNX AP, $125.

Thus QNX emerges as a clearly credible alternative to some old-favorite realtime systems. Although the QNX operating system seems to address a particular segment of the realtime executive market, to that segment it speaks well and in a complete voice.

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Gary Elfring specializes in writing realtime control software. He is the author of Microcomputer Assembly Language Programming *(Van Nostrand Reinhold, 1984).*

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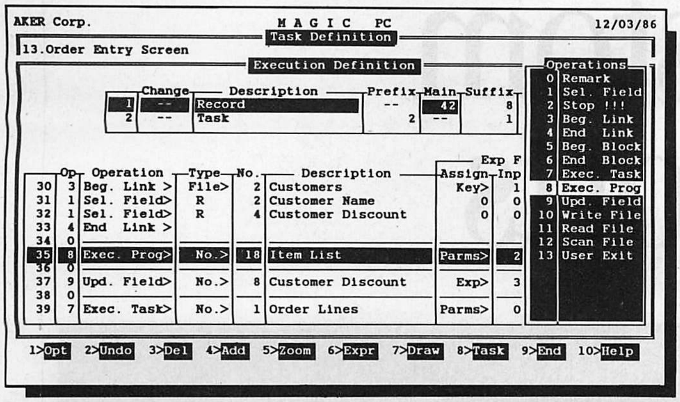

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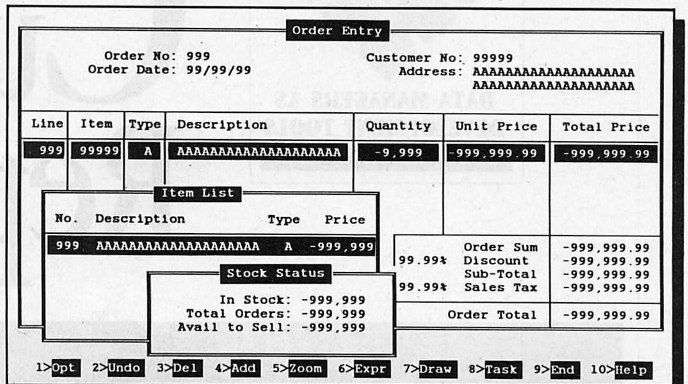

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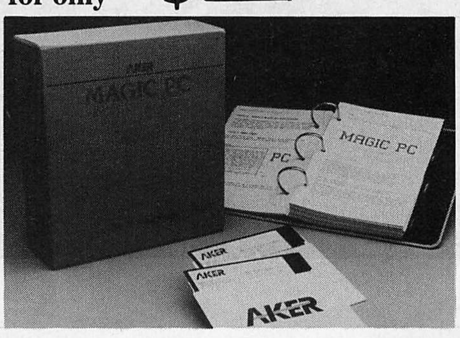

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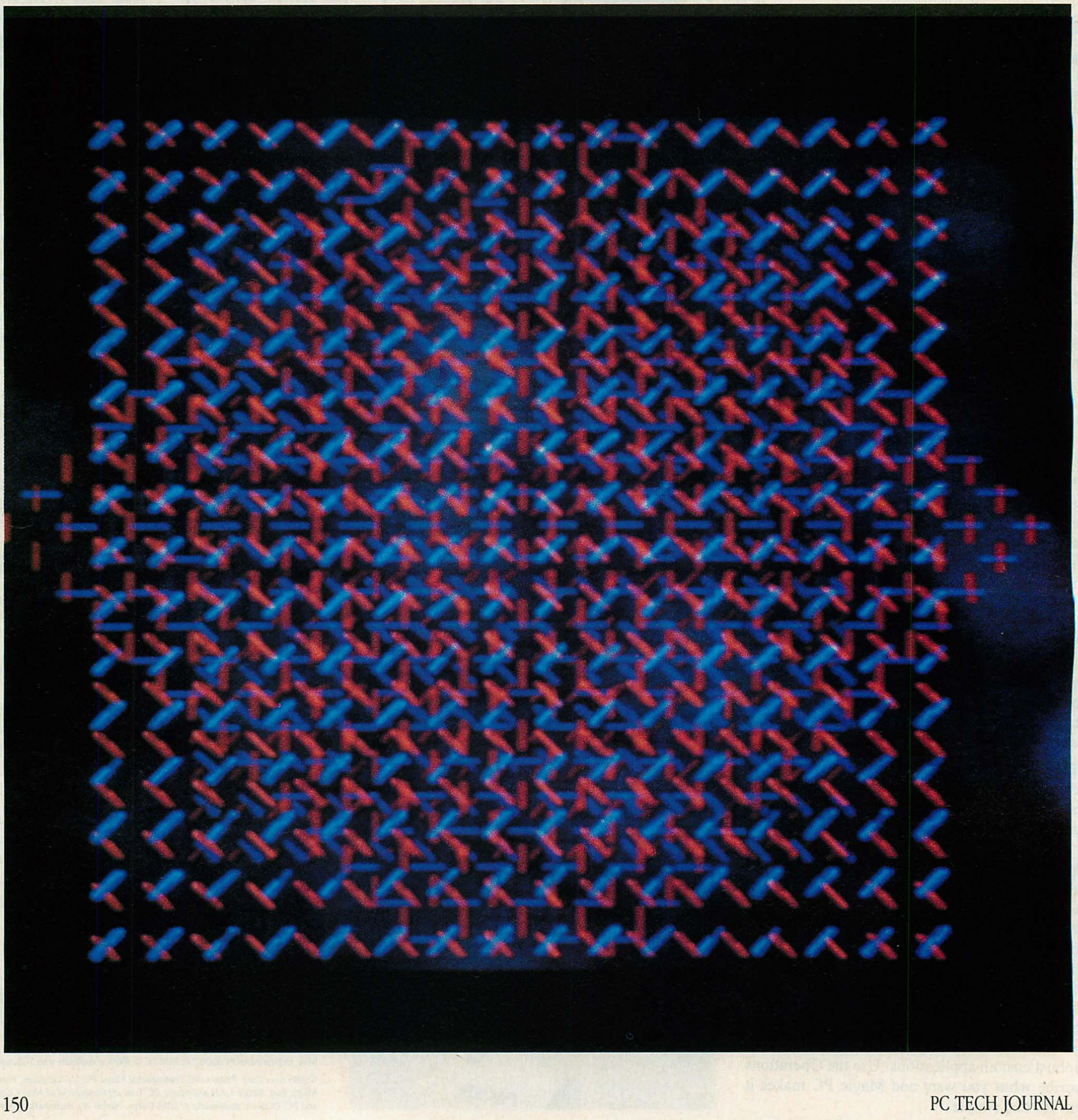

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The Data Edition and Reports+ modules of IBM's Personal Decision Series form a partnership that can manage files, generate reports, and develop custom applications.

DAVE BROWNING

Central to IBM's eight-program Personal Decision Series (PDS) for personal information management is a data management module called Data Edition. By itself, Data Edition is a single-file manager of modest data storage capabilities, but when combined with the PDS Reports+ module, the two products enter the arena of data managers with application development potential. BASIC programs generated by Reports+ provide reporting capabilities, including the combining and updating of multiple files, and can be tailored to support custom applications.

Data Edition is integral to the use of all other PDS programs. (Other modules in PDS address the functions of graphics, planning, word processing, and interfacing to IBM mini- and mainframe computers.) It is provided on three diskettes, with asynchronous communications on a fourth. Reports+ is provided on two additional diskettes. Neither program is copy protected.

Data Edition may be installed on any diskette-based system with a minimum of 256KB of memory, but a hard disk is highly recommended. An 80-column-by-25-line monitor (color or monochrome) is required. A printer, asynchronous port, and full duplex modem are optional. The documentation refers to the numeric coprocessor, but IBM does not make clear if the coprocessor is used if available.

The installation program checks CONFIG.SYS and modifies it if necessary to include a FILES=24 statement. A FILES statement with more than 24 files specified is not changed. The installation procedure also checks to see that BASICA.COM and COMMAND.COM are available on the root directory of the hard disk. The IBM version of the BASICA.COM program is not required, so Data Edition should be installable on compatible machines. However, interpreted BASIC programs generated by Reports+ do not run on compatibles because a binary program is made available at a specific address and called using the CALL statement.

Although IBM's documentation does not specifically state that Data Edition and Reports+ run only on IBM machines, it always assumes the system is operating in an IBM hardware environment with DOS 2.x or 3.x. A patch must be applied to correct an existing bug in COMMAND.COM in order to run Data Edition under DOS 2.0; other versions of DOS do not need modification. A procedure for applying the patch using DEBUG.COM is included in the installation appendix of the Data Edition documentation. In a concession to purchasers using non-IBM printers, Data Edition includes parameters for specification of alternative control character sequences for common printer settings such as print style and page length. These parameters may be modified from a menu in Data Edition.

Besides updating CONFIG.SYS and checking for the existence of BASICA and COMMAND, the installation procedure installs six programs and batch files on the hard-disk root directory. A subdirectory, PDSCMD, is created and loaded with PDS system executable, overlay, parameter, and configuration files. A library subdirectory is also initialized to contain PDS definitions, data files, and procedures. A tutorial, which includes a complete application with file definitions, data, procedures, and programs, also can be installed. A section in the documentation corresponds to the tutorial program.

Documentation consists of one volume each for Data Edition and Reports+. The books are presented in the familiar gray, 9-inch-tall, three-ring IBM binders and boxes except that the binders are 11 inches deep instead of the usual 8 inches. Page size is 8½ by 8½ inches. Quick-reference cards are provided with each program.

The documentation is of the how-to-use variety often produced by IBM. Details of underlying concepts and program implementation are not discussed. The "Using" section of the manuals is divided into subsections by task definition. A typical subsection includes discussion and examples of screens and option selection, common uses of the task, what the user will need to know in order to complete the task (such as names of fields to be used, sequence of records desired, calculations that will need to be made, etc.), and some "what if" questions that might arise during the performance of the task.

The appendixes includes sections on installation of the program or module, installation of tutorials, updating DOS 2.0, unusual operations (such as transferring data using DIF formats), descriptions of data types in alternate file formats, and so on. A glossary provides substantial information and additional detail on several subjects discussed in the "Using" section.

A separate section lists error messages, which are divided into three categories. PD messages refer to operations performed by the Data Edition module of the PDS system, such as "PD090 File Name is missing" or "PD108 MAINTAIN LIBRARY ended." Some messages indicate errors, others are for information only. PD messages with return codes indicate problems for which Data Edition cannot specifically identify the cause, such as a corrupted file internal structure that might have been due to a

power failure or a computer malfunction. B.RC return codes indicate errors such as incorrect file numbers in the BASIC program generated by Reports+.

Overall, the documentation is excellent and closely matches the program operation. A technical section or appendix on the details of the underlying design and structure of the programs that make up the PDS system also would be helpful.

Data Edition and Reports+ each have a 90-day warranty against defects. A pamphlet describes support service. Problems must be reported in writing, for which a reporting form is provided in a utility program (which automatically includes the package serial numbers, versions, and levels on the printed form). In addition, IBM offers optional extended support service at various levels for an additional fee.

TABLE 1: *Supported Data Types by File Type*

DATA TYPE		INDEXED	DIRECT	TEXT	BASIC SEQ	DIF
C	Character	●	●	●	●	○
N	Numeric	(Real8)	(Real8)	(ASCII)	(ASCII)	○
X	Skipped	●	●	○	○	○
S	Structure	●	●	○	○	○
P	Position	●	●	○	○	○
E	End of record	○	○	○	●	○
A	ASCII number	○	○	●	●	○
%	Integer	●	●	○	○	○
!	Single precision	●	●	○	○	○
#	Double precision	●	●	○	○	○
B	Single precision Business BASIC	●[a]	●[a]	○	○	○
D	Double precision Business BASIC	●[a]	●[a]	○	○	○

● = *Yes* ○ = *No*

[a] *This data type is available for all tasks that support that file type except Enter Data.*

Data Edition supports several different file and data types; fields that are specified for each file definition must use appropriate data types and sizes.

FILE TYPES

Data Edition recognizes and works with several data file types and field data types. Each file to be used with Data Edition must be defined in terms of file type and record structure. A file is named using DOS rules, and it can include a path. An optional description of up to 40 characters also can be specified. The available file types are: indexed, direct, text, BASIC sequential, DIF256, DIF128, and DIF96.

The program's internal files are of the indexed type and are stored in an unspecified internal ISAM (indexed sequential access method) structure. Direct files are fixed-length record files where record number is used for retrieval, as in BASIC random files. Text refers to fixed-field position files with CRLF record separators; Tab characters are accepted in TEXT files. The BASIC sequential file type corresponds to delimited files produced by BASIC or other programs. Comma field separators are required, but quotes around text fields are necessary only if the fields contain commas; the separator character must be a comma. DIF256 specifies a data interchange format file with translation of all ASCII characters. In addition to specifying format, the DIF128 and DIF96 file types perform character translation on export into the smaller 128- and 96-character sets required for some applications.

Files are imported and exported by copying from one file definition to another. Several Data Edition operations may be performed directly on some non-PDS files without conversion.

Error messages indicate that direct files can contain no more than 64KB records; other files are limited only by disk space and DOS limitations. Up to 11 indexes can be specified on a file, using single fields as keys. Any number of sort sequences can be defined on a PDS file. The sort definition pointer file contains record numbers of the data file records and can be restricted to a subset of the file. Indexes are automatically updated when data change; sort files must be rebuilt by command.

Fields are specified for each file definition using the appropriate data types and sizes. The number of fields allowed in a Data Edition file depends mainly on available memory. Appendix B of the Data Edition manual indicates that 40 to 100 fields may be defined in various circumstances. That appendix also provides a table that can be used as a planning guide to determine the approximate number of fields allowed in a file definition. Field data types for PDS files are character, numeric, structure, position, and skipped (or reserved). Other data types include end-of-record, ASCII numeric, integer, BASIC single and double precision, and Business BASIC single and double precision. Some data types are specific to some file types. No data types are available for date or time information. Table 1 shows which data types are supported by which file types.

Character fields (data type C) can have a maximum size of 40 characters, a serious limitation for many applications. Numeric fields (data type N) can be up to 14 digits. In indexed or direct files, numeric fields are stored as eight-byte floating-point numbers; in text or BASIC sequential files they are considered ASCII numeric fields of the length specified. Format information for numeric fields is used for display and rounding. Skipped fields (data type X) are used to reserve a number of positions in the record layout.

Structure fields (data type S) redefine subfields; for example, a date field could be defined as S6 with three C2 subfields for year, month, and day. Structure fields still must adhere to the 40-byte length limitation. Position fields (data type P) specify the starting position of the next field in a record or pad records to a specified length. This is useful when matching subfields in a direct file. An end-of-record field (data type E) specifies the CRLF end-of-record sequence in BASIC sequential files. Two-byte integer, four-byte single precision, and eight-byte double precision BASIC fields (data types %, !, and #, respectively) match the numeric data types of IBM BASIC direct files. For Business BASIC, four-byte single- and eight-byte double-precision formats are matched by the B and D data types.

When a field is specified in a file definition, data verification also can be designated. Three types of data verification are provided: a table of specific values (for character fields only), a range of acceptable values (for character or numeric fields), or a mask (for character fields only). Table and range verifications may specify whether uppercase or lowercase treatment is significant for character fields. During data entry, table verification values may be selected using the rotate function keys

(see photo 2). The entire verification table for a field is limited to a total of 40 characters, including the verification scheme code and value separator characters; this is a serious limitation of the Data Edition module.

A verification table consists of a delimited list of acceptable values preceded by a flag that indicates whether letter case is significant. An example of a verification table is "T,,male,female." If the initial letter *T* is made lowercase, then lowercase letters will not match uppercase letters; otherwise all letters are treated as uppercase. The value separator character is the first character following the code, a comma in this example. The null first table check value permits the field to be left blank.

Range checking is specified using the format "R,low value,high value." As in the verification table, the case of the code letter *R* determines if the case of character data is significant. Either low or high value may be left null to inhibit checking of one end of the range. Masks are used to specify special character arrangements, as in "m,(###) ###-####" for telephone numbers. Masks are valid only for character fields, and special characters must be manually skipped over during data entry. The mask characters are: # for digit 0-9, ! for upper/lowercase letter, % for letter/digit/blank, and \ accepts any character. Any other character is a literal.

Data verification rules can be set up within the file definition and remain in effect until the file definition is changed. These rules are displayed when data entry is performed, and they can be added to or modified for the data entry session. Screens defined in programs generated by Reports+ can include different data verification rules.

Multiple file definitions can apply to a single file as long as the key field remains the same and all commonly defined fields correspond in both order and position. Position fields can be used to skip fields. The primary use of a second file definition is to restrict the number of fields used by a report or process. This reduces the amount of processing required to convert the data between storage and processing format and thus improves performance.

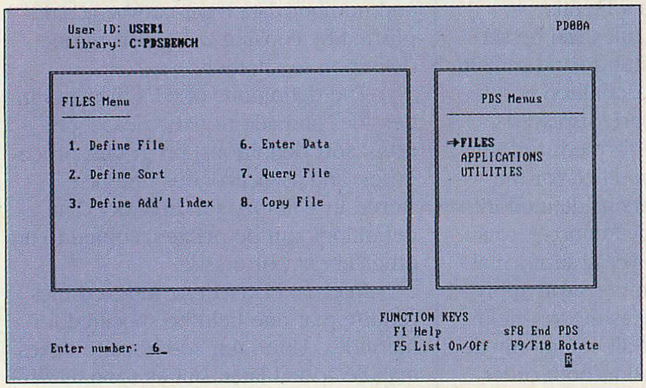
File definitions may be modified or used as the starting point for any subsequent definition. Changes to field names in file definitions must be manually carried over to associated sort and index definitions. Changing field sizes, other than increasing numeric display widths, requires the file to be copied to a new definition from the old definition in order to preserve data integrity. Conversion of a field between the character and number data types can be accomplished by copying the file from one definition to another.

The definitions of data files and index files and additional index definitions, sort definitions, programs, procedures, and asynchronous lines are stored in a library subdirectory. The definitions can be printed, copied to another library, or erased.

Internal PDS-format indexed files require that one field be specified for the index. Up to ten additional indexes may be added later, but as soon as all index definitions have been used, no more additional indexes may be defined even if some of the previous definitions are removed. Only one DOS file corresponding to the primary index key is created, so the additional index definitions apparently are stored in the library and/or the data file.

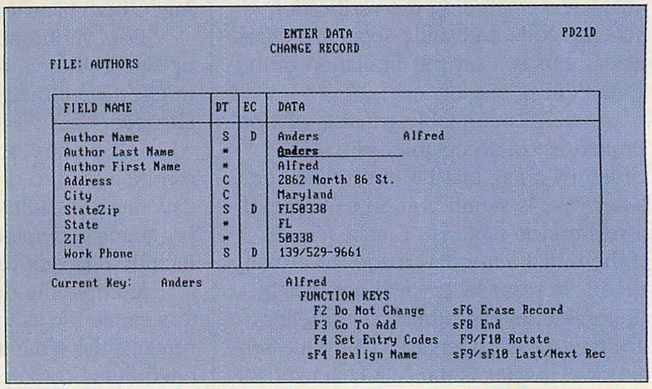
The internal ISAM data file structure is not specified, but examination of the file shows a header area and an area between each record where bytes are used for storage other than data. Index reference information appears to be stored in the data file header, which must be modified each time another index is defined. Each additional index

PHOTO 1: *Initial PDS Menu Screen*



Task choices for a specific menu are displayed in the left-hand box on the PDS menu screen as a pointer is moved through the list of menus in the right-hand box.

PHOTO 2: *Data Entry Screen*



Data are entered into fields on a tabular display. The layout of the standard data entry screen cannot be modified; however, entry codes for data verification can be changed.

definition is a separate process, so a file set up with several index keys can take some time to prepare, especially if it contains data. Index keys are single fields, but the structured data type may be used to split or combine adjacent fields for indexing. An index can be specified to be unique or to allow duplicate keys. To access a file in a secondary index sequence, the index definition is selected by name.

Sorts are defined separately in a manner similar to that in which additional indexes are specified. However, sorts permit up to ten field names to be identified for each sort definition, and each field in the sort can be sequenced in ascending or descending order. Also, record selection criteria can be specified using the Data Edition query screen to limit the records that are sorted. Sorts must be reexecuted after any data change in the data file and after the definition of an additional index.

TASK CHOICES

PDS operation depends on a system of menus and tasks. The main PDS screen, as shown in photo 1, includes a box for a list of task choices associated with one of the menus installed in the system. Task choices for a specific menu are displayed in the left-hand box on the screen as a pointer is moved through the list of menus in the right-hand box. Tasks may be combined in chains to form procedures.

Under the FILES Menu are the tasks associated with creating, modifying, and retrieving data from files: Define File permits manipulation of file definitions; Define Sort manages the modification of sort definitions and the execution of the sort to build the sort file; Define Add'l Index permits the creation of additional index keys to a data file; Enter Data provides for adding to and changing data in a data file; Query File manages the file query and reporting function of Data Edition; and Copy File is used to import, export, and manipulate data files.

The APPLICATIONS Menu lists the tasks used for defining and executing procedures and programs: Define Procedure manages the creation and modification of procedures, which are groups of tasks with optional parameters used to automate routine operations; Run Procedure executes a predefined procedure; Define Program executes the Reports+ module for the creation of BASIC source language programs; Run Program executes previously defined external programs, including BASIC source code under the BASIC interpreter, DOS .COM or .EXE programs, and .BAT files.

Two tasks are found under the UTILITIES Menu: Set PDS controls the PDS system configuration parameter options; in addition, it creates, switches, and erases PDS libraries. Maintain Library manages files (except data files) in the PDS libraries.

The COMMUNICATIONS Menu has tasks for defining and executing asynchronous communications sessions.

Because Data Edition has no command language or operations that can be used to alter multiple records in a file in a single process, the Copy File task under the FILES Menu becomes the workhorse for data manipulation. Both the source and target files must be defined to Data Edition using the Define File task before a copy can take place. External files used for data import must be defined as well as the internal files receiving the data. Instead of a file definition for the source file, Copy File accepts the name of a predefined index definition or sort definition. Using an index definition causes the processing of all records in the source file in the sequence of the index key field, whereas the use of a sort definition restricts the processing to only those records included in the sort (which may have used record selection to define the sort file as a subset of the original data file).

Transformations that can be performed during the Copy File task include definition of virtual calculated fields, selection of records to include or exclude from the source file, specification of source/destination field matches, modifications of format and conversion between character and numeric data types, and replacement of or appending to records in the destination file. With DIF files, no transformation processing beyond the use of index or sort definitions on a non-DIF source file can be performed during the copy process.

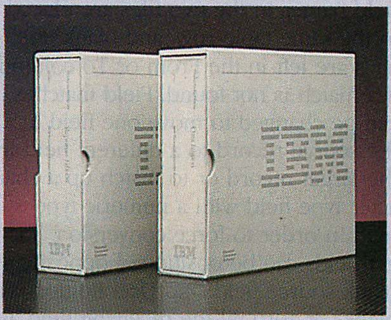
A table of calculations with up to 20 numeric calculation definitions can be specified for the process. The table contains four columns: the name of the calculated field, the first field name or value, the operator, and the second field name or value. Each calculation result is placed in the calculated field name (really a virtual field), and calculated field names can be used as values in subsequent calculations.

In addition to the four standard arithmetic operators (+,−,*,/), a percent operator calculates the percentage one number is of another, a variance operator computes percentage difference between two values, a blank operator provides simple assignment (used to change field names for reporting), and a crossfoot operator sums all numeric fields (including virtual fields) between two given fields. The calculations are performed on a record-by-record

DATA EDITION AND REPORTS+ OVERVIEW

Data Edition with Reports+ 1.0
IBM Personal Decisions Series
IBM Corporation, P.O. Box 2328
Menlo Park, CA 94025
CIRCLE 365 ON READER SERVICE CARD

Product description. Data Edition is a file-oriented data management program designed for general stand-alone use or to support a family of additional programs in the Personal Decisions Series, such as Reports+. The Reports+ module extends the capabilities to include multiple-file manipulation and BASIC source code application program generation.
IBM PC environment. Data Edition runs on an IBM PC running DOS 2.0 or later, with 256KB minimum (additional memory is used if available), two diskette drives or one diskette and one hard-disk drive, and a monochrome or color monitor. BASIC programs generated by Reports+ will not execute on non-IBM computers in interpretive mode, but they will execute if they are compiled.
Other environments. No other environments are supported.
Network support. A network version is not available.
Copy protection. The product is not copy protected.
Documentation. A single volume (9 by 11 inches) is provided for each module; the documentation includes an extensive tutorial section, reference section, appendixes, glossary, messages, and a quick-reference guide.
User interface. Control is provided by task menus rather than by direct command interface. Data entry screen layout is fixed unless Reports+ is



used to create custom screen programs. The use of function keys is consistent throughout. Keys F9 and F10 rotate values through data input field when a list of values is available.
Help facilities. On-line, context-sensitive help is available using function key F1.
File capacities. File capacities are not specified. Number of fields per file varies with the available memory and complexity of queries and reports.
File types. Internal ISAM, BASIC sequential (comma delimited) with or without CRLF record marks, text (column-oriented fixed field length), direct (fixed-length records accessed by record number), and DIF file types are provided. Many operations can be performed directly on external file types without conversion.
Fields and capacities. Character (up to 40-character maximum field length), numeric, skipped (placeholder), structured (collection of subfields), position, end of record, ASCII numeric, integer, single and double precision, and Business BASIC single and double precision fields are supported. It does not offer date or time data types.
Data entry. Only fixed-format, field-by-field data entry screen is provided. Limited range and table data validation checks may be defined.
Application development facilities. Groups of tasks may be collected and saved as procedures; programs generated by Reports+ may be integrated into procedures. Applications must be run in PDS environment.
Security. Not implemented.
Access to system facilities. DOS commands, batch files, and executable files are accessible; external program execution can be integrated into procedure definitions.
Queries and reports. The basic Data Edition module permits file, sort, or index definitions to be combined with record selection criteria on single files, with output to screen or printer and up to five total/subtotal levels. Query output on screen may be scrolled vertically and horizontally for viewing. Reports+ module generates BASIC source code for sophisticated report production.
Utilities. A library of up to 125 named items (such as file definitions, queries, procedures, sorts, and indexes) is maintained. Each item can have a 40-character description.
Data compatibility. The Data Edition module imports or directly operates on the file types listed above. Any file type can be copied to any other file type with some restrictions.
Distribution. The Personal Decision Series is marketed through IBM software product distributors and dealers.
Price. $275 for Data Edition, $165 for Reports+.
Support. A variety of paid support service levels are available from IBM.

—Dave Browning

basis; totals or record counts cannot be accumulated. A special name REC# function can be used to retrieve the record number from direct files.

After calculations have been defined, record selection may be specified. Up to 20 tests can be formulated in a table, designated *include* or *omit*. Each row in the table specifies a test (IF, AND, OR), a field name (including virtual fields defined in calculations), an operator (=,<,≤,<>,>,≥,C, NC,G), and a field name, value, or character string for comparison. The operator C stands for *contains*, NC for *does not contain*, and G for a *global* comparison using question marks and asterisks as in DOS. Character comparisons ignore letter case. Nesting of comparisons is provided using Data Edition IF-AND-OR logic in accordance with the rules of Boolean algebra. Separate tests are specified by using the IF operator for each, and tests (or groups of tests) are separated with the OR or AND operator.

The lack of parentheses in the logic makes complex conditions very confusing. The documentation gives

IF past due > 0 AND bal due > cred lim
OR past due > 0 AND last pmt < 831231

as an example to illustrate the use of a repeated test (past due > 0) in order to clarify the conditions to Data Edition. Another example set of selection conditions using multiple IFs, ANDs, and ORs is so complex that a test run would have to be made against carefully prepared test data in order to determine the results. In some cases, performing a second file copy operation may be preferable to specifying a nested condition to Data Edition. If a sort definition is used as the source file, any record-filtering conditions defined for the sort restrict the set of records presented to the Copy File selection process.

After calculations and record selection criteria are specified, the fields to be copied are designated. Another table of four columns with the headings From field name, Format, To field name, and Format is used to match fields for transfer. Data Edition fills in

the columns with field names from the source and target files and from the calculation specification table. Matching field names in the two files are placed in the same table row, and blank entries are left in the From or To columns if a match is not found. Field matches can be changed to move one field in the source record to a different field in the target record or to match up a character type field with a numeric type field in order to force conversion. Target fields can be positioned opposite a blank source field, and Data Edition will blank- or zero-fill the receiving field as appropriate. Calculated fields can be source fields as well as character literals. Numeric literals can be given a name in the calculation table for subsequent use in the select fields table.

Because Data Edition stores numeric values in eight-byte format, numeric data transfer is not affected by differences in field lengths between the two file definitions. Character fields are truncated or blank-filled on the trailing end to adjust for field length differences. Conversion of character fields to numeric data type follows common rules for taking the value of a string. Numbers converted to characters must fit within the length of the receiving field, or Data Edition will store blanks.

Many data manipulation operations are accomplished by the Copy File task, which can be flagged to add the copied records to the records in the destination file or to replace records in the destination file. If this file is of the direct type, a replacement copy writes the copied records over any existing ones and numbers them starting from 1. If the destination file is a Data Edition indexed file, then it is emptied before the copying task ever begins.

Because test conditions cannot be used in the calculation or field selection tables, a single copying process cannot be used to update a subset of records in the source file, but this procedure can be accomplished with two Copy File operations. The first step would erase the output file and copy only the subset of records that are not to be changed. The second step would select only the records to be changed and add them to the destination file. Copy File cannot combine multiple files into one or update one file from another.

Unlike some data managers, Data Edition allows the copying process to be interrupted. During the copy, the number of records read and the number written are displayed, and the Shift-F8 key combination is used to ask for confirmation prior to aborting. If a copy is writing records to a file where duplicate keys are not allowed, the process stops at the first occurrence of a record with a key that matches a record already in the file. Records copied before the duplicate was found are placed in the target file. Depending on the selection conditions, a subsequent copy might be defined with the add attribute to continue the copy.

PROCEDURES AND PARAMETERS

Most, but not all, screens and functions in the PDS system can be used from a procedure, which is a named group of tasks linked together in a sequence. Procedure definitions consist of a 40-character description and are stored in a library as are all other elements in the PDS system. To define a procedure, a list of tasks, such as Copy File, Define Sort, or Run Procedure, is specified. Each task is then defined by filling in the task's screens of parameters as they are presented by Data Edition. To build nested procedures, the Run Procedure task is selected. The depth of nesting is apparently unlimited.

During the task definition process, a question mark either by itself or with a number from 1 to 10 is used to specify a deferred substitute parameter. If the question mark alone is used, Data Edition queries the operator for the parameter's value when the procedure is run. For example, a report may require a sort and query to be performed on a data file that might vary according to the day of the week. The operator could be queried for the data file definition name as part of the procedure when it is executed. Substitute parameters using the question mark with a number are specified in a table at the time of procedure definition. This parameter table, with the values selected when the procedure was defined shown as default entries, is displayed to the operator when the procedure is actually run. The default entries may be either retained or modified.

Nested procedures can use substitute parameters. A procedure using substitute codes ?1 – ?10 uses parameters from the calling procedure to override values specified when the lower-level procedure was defined. An example of using nested procedures would be to define a low-level procedure to be performed daily, an end-of-week procedure that calls the daily procedure before completing its process, and an end-of-month procedure that calls the end-of-week procedure prior to producing the end-of-month report. The procedure tree may be started at any level.

Procedures are stored in a library, along with items such as definitions, files, other procedures, and programs. The PDS system's library management is excellent. Different library subdirectories may be used to separate applications, and common data may be referred to from more than one directory. Each library is limited to 125 items, including the 40-character description entered when the items were defined. When an item is to be selected in other Data Edition operations, the item names and descriptions are presented to the user as a rotate table that can be stepped through using function keys.

The Maintain Library task is used to manage the items in a library. A set of items can be selected by specifying the item type (all, filedef, addlindex sortdef, program, proc, async, or file), a specific item name, or a set of item names. Once selected, specific items (except data files) can be printed, copied to another PDS library, or erased.

The Set PDS task is used to create new libraries, select a different library, erase an entire library, and specify printer settings, printer control characters, monitor display attributes, and the default start-up menu. Different default parameters can be saved in connection with different user IDs, which are created by starting PDS from DOS with the command PDS newID. Subsequent executions of PDS with a user ID parameter invoke the default settings for the specified user.

The printer parameter screen includes a setting for a print buffer length. The PDS-managed print buffer, which is specified in multiples of 512 bytes, subtracts from the memory that is available for other PDS tasks. The F7 print key used to print item definitions bypasses the print buffer, so buffered printing should be used with care. Printer control character settings can be specified for normal, compressed, double width, double-width compressed, form feed, six lines per inch, eight lines per inch, and form length. A separate screen is available to set control characters for color printers.

Settings for monitor displays include redefinition of colors and highlights for text and messages on the PDS screens. Users with two screens may save settings for both. A setting for the default menu to be displayed when PDS is started also can be saved.

USER INTERFACE

The user interface consists of various screens and menus. In some cases, the cursor control keys can be used to position a pointer, as in the selection of a menu on the main screen. In other cases, the user response must be typed into a highlighted area. Selections can be confirmed using either the Ctrl-Enter key combination or the plus key on the numeric keypad.

A consistent definition of function key assignments is maintained throughout PDS. A list of active function keys is displayed at the lower right-hand corner of the screen: F1 produces a help window when appropriate and pages through the help shown in the window; F5 toggles a list feature, which captures PDS definitions as work is accomplished and prints them when the task is exited; F6 and Shift-F6 insert and delete items; F7 is an immediate print of the currently selected item; F8 is used to return from a subfunction, and the Shift-F8 combination either aborts a process without saving changes or ends a function with changes saved, depending on the operation in process.

A highlighted, uppercase *R* indicates when the rotate keys are active. When PDS expects the user to select a value from a defined list of options (whether displayed or not), function keys 9 and 10 rotate the list of options through the user input box. F9 moves the list in one direction, F10 moves it in the reverse direction. The rotate feature is convenient for selecting items when working with file definitions from the list of files, and it also is used to select items from data verification tables assigned to field definitions in files.

PDS has a standard data entry screen (photo 2), the layout of which cannot be modified. Entry codes for data verification can be specified or changed for the data entry session, but at the end of the session they revert to the verification settings stored in the file definition. The data entry screen provides for entry of data into fields on a tabular display. Function keys are used to change modes. When in change mode, the key field is displayed below the data entry box, and a new key is presented. If a direct file is being updated, record numbers, instead of index keys, are used for selection.

The basic Data Edition module of the PDS system provides the ability to query and report from a single file. Output may be viewed on the screen, printed, or directed to a file. In addition, queries can be run on direct, indexed, text, or BASIC sequential files.

For PDS files, a file, index, or sort definition can specify the input data file. Sort definitions can restrict the scope of records retrieved from the underlying

data file as well as designating a sequence. When directing output to a printer, the default print style of normal or compressed specified by the Set PDS task can be overridden. Final totals and up to four additional subtotal levels can be specified. A query title of up to 40 columns can be assigned and is stored in the library if the query is saved as a procedure. Query output is column oriented, and output can be tailored to include title and column headings, to display summary or detail, to select fields and arrangement to be displayed, to specify column width and spacing, to calculate virtual fields for interim use or output display, as well as to skip lines and eject pages.

Record selection uses the standard IF-AND-OR logic of the PDS system by which records can be selected for inclusion or omission in the output report. Calculated fields, which are specified under the Copy File task as described above, may be used in the record selection criteria. The predefined REC# function incorporates direct file record numbers for record selection and output. Two character fields can be trimmed of trailing blanks and joined with zero or one space between the results when the output is directed to a file or the printer. Literal symbols such as the vertical bar (|) are used for output formatting. During the output tailoring process the F2 function key can be used to compute the current width of the report to reduce the time spent testing reports on the printer.

When Data Edition files of the indexed or direct type are the source for a query and output is directed to the screen, the PgUp and PgDn keys can be used to scroll forward and backward through the output. This is not possible for other file types. Horizontal scrolling of output that is too wide for the screen is permitted. During scrolling of a query output, the F3 function key can be used to display a table that shows all fields in a selected record; F7 can be used to print the table.

The standard query and report functions that are provided by the basic Data Edition module produce attractive column format reports with reasonable calculation and subtotaling options from within a single file.

AN ADDED DIMENSION

When the PDS Reports+ module is installed with Data Edition, an additional dimension of data management is thus added to the PDS system. Reports+ is a source code generator that produces BASIC language programs to operate in conjunction with PDS data files. Programs that provide for multiple file access, user-defined screens, and substantial output formatting may be produced without additional user programming. User-tailoring of programs produced by Reports+ can add more complex calculations, determine alternative processing sequences, and provide specialized error processing.

Reports+ is accessed from the PDS system by selecting Define Program from the APPLICATIONS Menu. As with all PDS tasks, program definitions are stored in the library and may be modified or used as a starting point for new program definitions. The usual 40-character description line is available to help identify existing program files as they are rotated through the selection box on the Select Program screen. Once a program has been selected or a new program name entered, a screen of seven options is presented: Select Files, Specify Summary Breaks, Specify Forms Control, Define Report Format, Define Screens, Enter BASIC Statements, and Build Program and End. In addition to

these options, Reports+ can be directed to use either the report or the freeform program skeleton and to produce code either for the BASICA interpreter or the IBM BASIC compiler.

The Select Files option includes the specification of files and fields to be used, input and output methods, calculations to be performed, and records to be selected. Up to six files (F1–F6) previously defined to PDS may be selected for use by the program. For each file, the input method is specified as sequential, random, demand, or blank (not used for input) and the output method as update, add, demand, or blank (not used for output).

The update output method makes changes to existing records. A record written to the output file after a successful read causes the record to be updated; otherwise, a new record is added to the output file. The add output method allows adding to the file only. An input method cannot be specified for output files using the add mode. The demand output method requires that user code execute a B.WRITE request when output is desired.

For input files, options may be executed for the selection of fields and records and the definition of calculations. The usual PDS screens are used to support these options. Up to 200 fields may be selected for a program, including file and calculated fields.

The Specify Summary Breaks option permits up to five summary breaks with summary line titles. The break fields may be selected from file fields, calculation fields, or a BASIC variable name to be manipulated by user code. A special field name EOF is used to select processing that should occur at the end of the program. In addition to report output formatting, summary breaks can be used to determine when special processing, such as updating or adding records to files, should occur.

The Specify Forms Control option uses a screen to collect specifications for printer control elements, such as lines per inch, form size, print style, output file name, printer ID.

Under the Design Report Format option, which supports the definition of the output report layout, line types are available for header, detail, summary leader and summary lines, footers, and user lines (printed with user code B.PUSER statements). Each line is defined with line skip spacing, print style, text, and field locations. Colors may be selected for color printers. Formatting symbols specify field locations and print formats. Special value types for current, subtotal, average, running total, and previous can be assigned to formatting symbols to designate the source of the field data to be printed.

Ten screens (S1-S10) can be defined and used in the program with the Define Screens option. Screen definitions are saved within PDS, and a 40-character description can be assigned for future reference. Screens can be designated for one-time display at program initialization (to collect starting values or parameters) or on demand based on B.SCREEN or B.INVSCREEN requests in user-added BASIC code statements. The Reports+ module provides cursor control scrolling.

Screen sizes can be larger or smaller than the monitor display size. Screens that are smaller than the monitor display can be positioned anywhere on the monitor. The screen format is painted on the blank screen, colors are selected, and formatting symbols used for up to 50 fields on a screen. The sequence in which the cursor moves from field to field can be specified, and the data verification rules described above for Data Edition can be used for fields that accept data. Field alignment (left, right, or character left/numeric right) also can be specified.

The Enter BASIC Statements option invokes the BASIC interpreter for editing the Reports+ program skeleton. After user code is entered, the program is saved and control returned to PDS. Build Program and End completes the program generation process by merging user code into the program built by Reports+ and saving it as a BASIC ASCII file with the extension .@BS.

The Define Program task allows the user to generate sophisticated report and data management programs using Reports+ without additional programming. Multiple files can be linked, data from one file can be used to update another, data from multiple files can be combined into one, and special screens can be defined to display data and accept data entry. The incorporation of BASIC statements into the program is necessary to access up to two additional non-PDS BASIC files, rearrange the sequence of program processing, add complex calculations, and perform specialized error processing.

Data Edition's Run Program task executes programs generated by Define Program. If the program is generated in the interpreter build mode, the BASICA interpreter is called in to perform the execution. For programs generated by

Reports+, additional parameters can be specified to override the printer destination ID, redirect the output to a file, set parameters, and specify alternative file names to be used in the program. Another option for interpreted programs is to select execution in a test environment. This means that control remains in the BASICA interpreter instead of returning to PDS upon program termination, a useful feature for debugging user-generated code statements.

Tailoring of programs produced by Reports+ can be as simple as the addition of one or two statements to define additional calculations for a summary total in a report program skeleton or as complex as the development of a complete program within the Reports+ freeform skeleton. Programs can be compiled with the IBM BASIC compiler for improved performance.

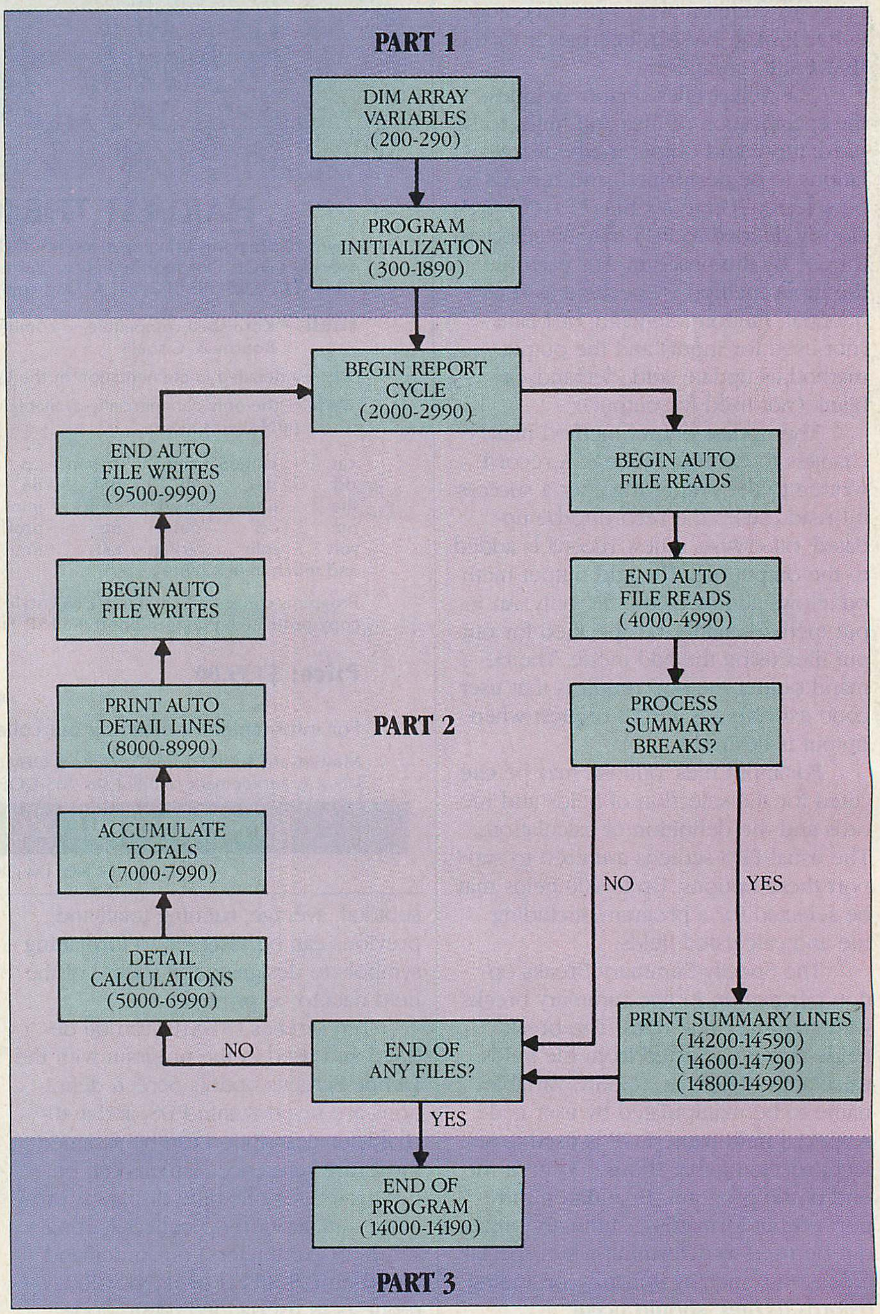
The modification of a report format skeleton is straightforward, once the underlying concept is understood. The report program skeleton has three main parts: initialization, report process cycle, and final processing, which performs any special processing required at program completion and closes files. Initialization consists of two sections, one to dimension arrays and the second to perform tasks, such as initializing variables, establishing printer controls, assigning default and runtime parameters to variables, and displaying screens.

The report process cycle is divided into the following steps:

- **Begin report cycle** performs any processing, such as variable resetting, that must be done at the beginning of each report cycle.
- **Begin auto file reads** performs the read operations for sequential and random files and checks selection criteria until a record passes the tests; no user code can be entered.
- **End auto file reads** is executed after input has been accomplished; user code can be entered in this section to control the reading of files specified as demand input; other calculations such as special summary breaks can be entered in this section.
- **Process summary breaks** checks to see if any predefined break conditions have been met. If any have occurred, the program branches to subroutine sections for calculations prior to summary printing and prior to each level of printing, where user code may be incorporated. The predefined summary line is printed, and the section for calculations after summary printing is executed. After break processing, the program checks to see if an end-of-file condition has occurred and, if so, branches to the final processing part of the program skeleton.
- **Detail calculations** performs calculations such as accumulation of totals or preparation of detail output data.
- **Accumulate totals** calculates predefined totals such as subtotals, averages, or running totals.
- **Print auto detail lines** prints the report detail line and any user-defined lines to be printed with the detail.
- **Begin auto file writes** is executed next to perform any automatic file updating that has been specified in the program options; user code is not allowed in this section.
- **End auto file writes** permits user code to be specified for additional file output manipulations. This section also ends the report cycle, so any additional steps to be completed at the end of the cycle are programmed here. The program then loops to the beginning of the report cycle.

Figure 1 is a diagram of the program control flow. In a freeform program, the user must specify the se-

FIGURE 1: *Report Program Control Flow*



The Reports+ report program skeleton consists of three main parts as indicated above: initialization, report process cycle, and final processing.

FIGURE 2: *Freeform Report Skeleton*

```
1     OPTION BASE 1
2     DEFDBL A-Z
195   '------------------------------------------------
196   '      DIMENSION ARRAY VARIABLES         (USE  00200-00290)
292   GOSUB 15100
295   '
296   '      FREE FORM CALCS                   (USE  00300-13790)
13791 STOP
13794 '------------------------------------------------
13795 '
13796 '      USER ERROR PROCESSING             (USE  13800-13990)
13993 GOTO 15300
13995 '
13996 '      CALCS AT END OF PROGRAM                    (USE  14000-14190)
14193 B.REQUEST=B.REPEND: GOSUB 15000
14194 '------------------------------------------------
14195 '
14196 '      CALCS PRIOR TO ALL SUMMARY PRINTING  (USE  14200-14590)
14591 RETURN
14595 '
14596 '      CALCS PRIOR TO EACH LEVEL PRINTING   (USE  14600-14790)
14791 RETURN
14795 '
14796 '      CALCS AFTER ALL SUMMARY PRINTING     (USE  14800-14990)
14991 RETURN
14995 '----------------(End of User Added Code)--------------------
```

The freeform skeleton is a subset of the report skeleton. The user develops the processing sequence in the freeform calcs section.

quence of processing, using the thirteen requests and two functions available from Reports+. The two functions, GET and REPLACE, manage summary and line count variable data.

A request is a call to a subroutine after setting a variable to perform a specific function such as reading files or printing lines. The requests are: B.ADDSUM to accumulate totals and record counts, B.CLOSE to close files, B.INVSCREEN to display and read a screen, B.LASTREC to save values from one record for processing of the next record, B.PDETAIL to print detail lines, B.PROCPARM to manage runtime substitution parameters, B.PSUM to detect and print summary breaks, B.PUSER to print a user-defined line, B.READ to read a record, B.REPEND to end the program, B.SCREEN to display and read a screen that has complex screen operations, B.SKIPLINE to force line skips, and B.WRITE to write or delete a record.

About four dozen variables used by Reports+ in the generated program are available for user query and modification (not all variables). An example is the B.LASTLEV variable, which contains a number (1-5) corresponding to the summary break level that just occurred when in the process summary breaks section of the program.

The freeform program skeleton, shown in figure 2, is essentially a subset of the report program skeleton. The programmer is responsible for developing the processing sequence within the freeform calcs section. All file input and output must be in the demand mode and is accomplished using the appropriate predefined request subroutines. Screens can be manipulated using the request subroutines just as in the report format program.

When Reports+ builds a program, it generates program statements within the requested skeleton in response to the options specified by the user. The user code is merged with the generated program to define the complete program. Because Reports+ makes use of predefined line numbers for user code sections, changes can be made to a previously developed program without destroying user code. The resulting BASICA program is stored in ASCII with the .@BS extension. It is not stored in line number sequence because the BASICA interpreter sorts on line number while loading. When using the program in the interpreted mode, it can be saved in BASIC tokenized form, which speeds up the loading and storing process. Before a generated program is compiled, it must be loaded into BASIC and resaved in ASCII to sequence the line numbers properly. The program should not be renumbered.

Because BASICA does not read the internal PDS ISAM file format directly, PDS must be used to provide the input/output interface for the programs. When Reports+ is used to generate a program for compiling, statements are created to call the interface module, PDSSTNG.OBJ, which is provided for linking with the compiled BASIC program. A CALL ABSOLUTE statement is used to access the PDS input/output routines. For interpreted BASIC processing, a binary program, which is available at a specific address, is called using the CALL statement. Therefore, programs that are generated by Reports+ must be run from the PDS system. Both versions of the generated programs check for the presence of PDS and halt with a message that PDS is required if it is not found.

Because of this linkage to PDS, programs generated for interpreted mode execution would not be expected to run on compatible machines using MS-BASICA instead of IBM BASICA. Indeed, they do not run on a Compaq using PC-DOS 3.1 and MS-BASICA. Reports+ programs can be compiled and will run with PDS on a Compaq, but this makes for a cumbersome development and debugging process.

APPLICATION DEVELOPMENT

Application development using Data Edition and Reports+ consists of defining custom BASIC programs within the report or freeform structures and integrating their execution into an application using Define Procedure. Applications are subordinate to the PDS structure, and end users must learn the PDS operating environment. Applications for markets other than those using or willing to learn the PDS interface would not be appropriate.

The Reports+ module provides a screen generator function as well as program skeletons. Up to 10 screens can be defined for a program, with as many as 50 fields on a screen. Screens can be larger or smaller than the physical display, and Reports+ manages the user interface for any necessary scrolling. Screens can be integrated into programs as initialization screens, which are automatically presented to the user before the processing loop begins, or as demand screens, which must be scheduled by user code in the program.

Field management on screens can be relatively simple if Reports+ creates the code for the user interface to fields; most applications, however, require a more direct interface between the screen program code and the developer's tailoring code. Data entry validation for fields in screens generated by Reports+ is limited to the restricted table, range, and mask techniques used in Data Edition. Any additional data validation such as look-ups in separate files requires the developer to manage the field presentations within the screen using the B.INVSCREEN and B.SCREEN program functions.

For applications to be used within the Data Edition environment and sub-

ject to the limitations of the Data Edition file structures, custom screen management and report programs are relatively easy to create after the Reports+ development system is learned. Applications that require data validation or file and field capacities beyond those provided by Data Edition will require substantial effort to tailor Reports+ skeletons into suitable programs.

The sample application used by *PC Tech Journal* to evaluate the data managers in this series stretches the PDS capacity and requires substantial effort to define within the Data Edition and Reports+ capabilities. (For a detailed explanation of the sample application, see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46.)

The sample application includes generation of an interactive data entry screen requiring look-up and data validation from two other files, data validation of one field dependent on validated data entered into previous fields, and on-screen calculations. The programming effort for this task is formidable, even within the Reports+ skeleton. Substantial programming effort is required because of restricted field types (no date fields) and field capacities (maximum 40 characters of text).

Implementation of the *PC Tech Journal* application as defined would not be appropriate for the combined Data Edition and Reports+ system. A subset of the sample application, which requires less data validation and accepts the restrictions on field capacities, could be accomplished within the natural use of the tools provided by Data Edition and Reports+.

BENCHMARKS

The benchmarks for the standard *PC Tech Journal* testing of data managers were run on the same 6-MHz PC/AT in the same fresh disk partition. The results are shown in figure 3. The first benchmark imports a 900-record file from AUTHOR.ASC, the comma-delimited file. Data Edition reads delimited format files directly after a file definition has been prepared, but the restricted operations that can be performed on files of this type mean the file must be imported to the internal Data Edition indexed format. If the fields in the file to be imported contain character data in the desired format, then this is a one-step operation using the Copy File task. However, the AUTHOR.ASC file contains telephone and Social Security numbers without separation characters, and the desired final format uses the slash (/) and hyphen (-) characters for readability. In addition, a structured field containing the state and zip code fields needs to be established for the creation of the secondary index on this combination for the second benchmark.

Structured fields cannot be defined on delimited file formats, so the first step is to import the file into a format where structured fields can be defined. Because this is an interim file only, the direct format (equivalent to BASIC random format) is selected for improved performance. Writing and reading a direct file in sequence eliminates the processing and input/output effort required to maintain index information. The field definitions in the interim file use structures to combine the state and zip code fields into a virtual **statezip** field. Other structured fields define the digit subgroups in the telephone and Social Security number fields. A second Copy File task is then defined to copy this direct format interim file to the final indexed AUTHORS file.

The final AUTHORS file layout also includes structured fields for the telephone and Social Security numbers, but subfields must be defined to hold the separator characters. For example, the Social Security number field of nine characters in the delimited file becomes a structured field, SSN, of nine characters containing subfields SSN1, SSN2, and SSN3 of three, two, and four characters in the interim direct file. The final AUTHORS file includes an 11-character SSN structured field containing the subfields SSN1, SSN1a, SSN2, SSN2a, and SSN3. SSN1a and SSN2a receive the literal "–" during the Copy File operation. These structures are cumbersome and interfere with many operations, so a third file format might be defined for final production use in order to eliminate the substructures.

For the benchmark test, the file definitions and the Copy File tasks were predefined, and a procedure was prepared to execute the two tasks automatically. The resulting benchmark time is the total for the two tasks.

In a production environment where a delimited file such as AUTHOR.ASC would be imported frequently, it might be more efficient to develop a custom program through Reports+ using the freeform program template. Such a program could read the delimited file directly, and customized statements would perform the field reformatting and specify the writing to the final file format. The execution time for this program would be expected to be less than the total time required for

the two Copy File tasks, but would probably be slightly longer than the time for the second copy to the final format where the index is built. The second copy from the direct to the indexed format took about three-fourths of the total time. Thus, a custom program should reduce the overall benchmark time by up to 25 percent.

The second benchmark requires the creation of a second index on the AUTHORS file, using the combined state and zip code fields. Because Data Edition permits indexing only on a single field, a structured field must be used to define the combination of two or more adjacent fields for indexing purposes. This field structure was specified in the AUTHORS file definition for this purpose. The Create Add'l Index task was used to perform the benchmark.

The third benchmark involves counting unique state occurrences in the state field in the AUTHORS file. Because no function is available in Data Edition for counting records, a custom program was required. The Reports+ report format program was used with a single, tailored BASIC statement added. In the section called calcs prior to each level printing, the BASIC statement

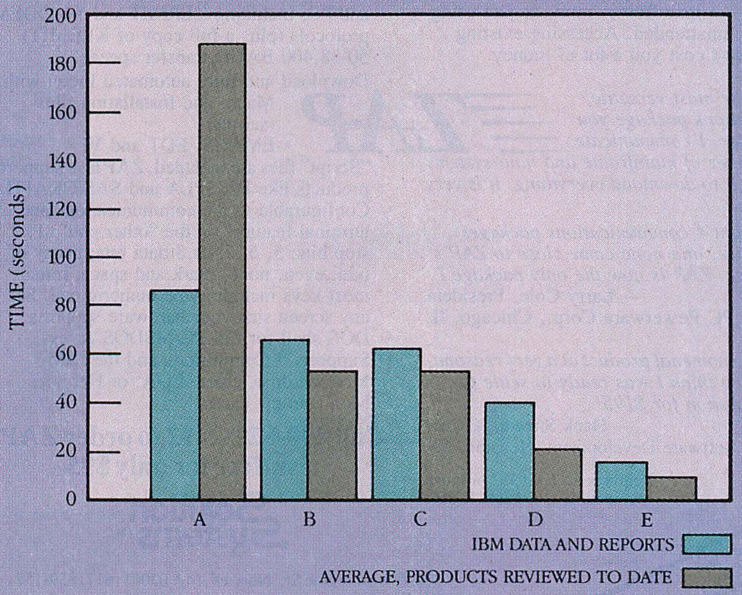
```
STATE.COUNT = B.CNT(B.RUNNING) –
    B.CNT(B.LEVEL)
```

was added at line 14600. This defined a BASIC variable, STATE.COUNT, to be the difference of two program registers provided in the Reports+ program. The array B.CNT held running counts of records read at each break level. The subscripts B.RUNNING and B.LEVEL were also provided by Reports+. In the report format design task, STATE.COUNT was used on a summary line as a variable to be printed, and a break was specified on the state field. This produced the tally output as long as the AUTHORS file was read in state sequence. The program was compiled using the IBM BASIC compiler version 2.0. The /O option was used to create a stand-alone .EXE program not requiring the runtime library. A sort definition task was specified to produce a sort in state sequence, and a procedure was defined to perform the two tasks in sequence for the benchmark test.

In the fourth benchmark the task is to replace all occurrences of the state "CO" with "CL" in the AUTHORS file. This could be accomplished with two File Copy procedures, where the first procedure selects records with "CO" and uses a literal to replace the state field with "CL." The first copy would use the replace option to empty the

FIGURE 3: *Benchmark Results*

BENCHMARK TASK	TIME
A. Add 900 records to an empty database table	86
B. Index table on two fields (7 bytes)	65
C. Document and tally codes from one column	61
D. Mass change of one column (28 rows of 900)	40
E. Extract selected records to create a text file	15



All times are in seconds.

All benchmarks were run on an IBM PC/AT (6 MHz) with 640KB memory. The tests were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.

The Data Edition and Reports+ combination was faster than average on the first benchmark, but its performance is about average or slower on the remainder.

output file. The second task would select records with "CO" to be omitted from the copy, and the "add" option would be used to append these records to the result of the first copy. To get the records back into the AUTHORS file, a third copy would be required. This approach, while it requires no programming, would be unreasonably long and, therefore, would probably not be used in a production environment.

Therefore, again a custom program with only one line of BASIC code was written under Reports+. At line 4000 in the **end auto file reads** section, the BASIC statement, F1STATE$ = "CL," was inserted. The Reports+ options were used to define a program to read the AUTHORS file in sequence and to specify the UPD option to cause the records to be rewritten after reading. Selection criteria in the Reports+ program specification limited the records presented to the custom BASIC code to those records having the state field equal to "CO." The benchmark was obtained by executing the Run Program task from the APPLICATIONS menu.

The final benchmark produces a delimited file of California author records in zip code sequence from the AUTHORS file. A procedure of two tasks was used to create this benchmark. The first task was a sort of the AUTHORS file on the zip field, with record selection criteria limiting the sort pointers to State = "CA" only. The second task in the procedure was a Copy File from the sort definition to the AUTHCAS file, which was predefined in the desired delimited output format.

A second approach was tried for this benchmark as well. An interim file, AUTHTEMP, was defined as an indexed file with the index on zip code. A procedure of two tasks was then specified to copy records from AUTHORS to the AUTHTEMP file for State = "CA." AUTHTEMP was then copied to the delimited AUTHCAS in the second task. This eliminated the need to sort the AUTHORS file. The second copy task took about the same amount of time as the second task in the first approach; however, the first task, copy from AUTHORS to AUTHTEMP for State =

"CA," took almost twice as long as the sort with record selection.

Data Edition and Reports+ score high marks for quality, consistency of design, and tutorial materials. Documentation is good, but lacking in technical detail of underlying program operations, interfaces, and file structures. File storage capabilities are weak in the area of data type choices and field capacity. Support for data verification is minimal, and program generation is required for all but the simplest data entry screen layouts. Report generation is the strongest feature of the combination; the basic Data Edition module supports definition of excellent column-oriented reports from single files, and the Reports+ module can generate superior report production programs that provide for multiple file access with little or no user code modifications.

Although the tutorial and training materials are excellent, a substantial investment in effort is required to learn the product. The overall system design of tasks and options requires the user to know what will happen before starting tasks and selecting options. This interface is professional, logical, and effective once learned, but the limited single file data management capabilities of Data Edition provide a meager return on the investment for the end user.

For the developer working in a BASIC language programming environment, the Reports+ module produces well-designed programs with excellent reporting capabilities, and the customizing procedures for tailoring generated programs are well documented and straightforward. The lack of provision for developing programs to read PDS data files except when PDS is loaded restricts the market for custom development. A runtime module that could be used to produce reports from PDS files would be a useful addition. The restriction that prevents generated Reports+ programs from running in an interpretive environment except on IBM computers makes the system unsuitable for users with compatible equipment using MS-BASICA who will need to develop reports from multiple files. In the appropriate environment, however, the combination of the Data Edition and Reports+ modules of the PDS system could be an excellent choice.

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Pixel Alignment of EGA Fonts

By using the EGA's graphics data controllers, programmers can display character strings both horizontally and vertically on the screen.

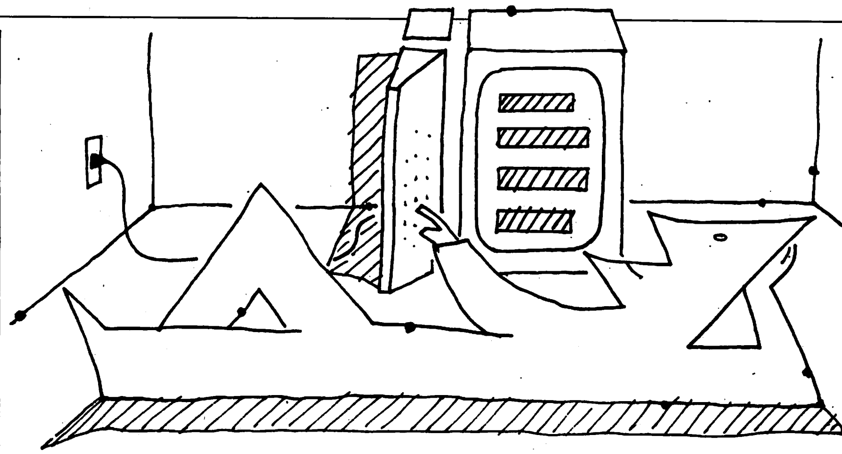


ILLUSTRATION • MACIEK ALBRECHT

The standard BIOS of the IBM Enhanced Graphics Adapter (EGA) provides only limited character painting in high-resolution graphics modes. Characters or strings must be positioned on the screen at even byte boundaries and only in the horizontal direction. To many programmers, this does not create an inconvenience because the high resolution of the screen renders the byte alignment inapparent. However, the ability to align character strings precisely to any pixel improves the appearance of graphics and allows programmers to animate smooth string movement across the screen.

To address these limitations of the EGA BIOS, a pair of assembly language subprograms (listing 1: EGAFONT.ASM and listing 2: STRINGER.PAS) use the EGA's graphics data controller (GDC) to place horizontal or vertical character strings at any pixel position on the screen using font information from the EGA ROM BIOS. (For a discussion of the EGA's functional anatomy, see "The EGA Standard," John T. Cockerham, October 1986, p. 49.)

THE GDC

The EGA actually contains two GDCs. Neither one is used in text modes, but in graphics modes each controls two of the EGA's four planes of graphics memory. The flow of data within the GDC is depicted in figure 1. The formats of the registers that control the GDC are listed in figure 2. Many of the EGA's registers perform multiple functions by accepting an *index register* that selects one of several internal registers residing at a single I/O address. The notation "3CF.2H" means that an index value of 2 is within EGA register 3CFH.

The GDC control of the two EGA bit planes is transparent to the programmer. Each bit plane has a latch that is filled when the system's CPU fetches a byte value from the video RAM. Although all four latches are filled on each CPU read, only the currently selected bit plane places its data onto the system data bus. During CPU writes, the latches are bypassed, and all of the bit planes receive the same data byte from the CPU's data bus. If one or more bit planes are *not* to receive that data, those planes must be explicitly disabled prior to the CPU write operation.

An 8-bit wide arithmetic logical unit (ALU) in the GDC manipulates data being routed toward the bit planes. The ALU can perform four logical operations—AND, OR, XOR, and MOVE—on its two operands, the data in the bit plane latches and the data from the CPU bus. MOVE simply copies bits verbatim from the CPU data operand.

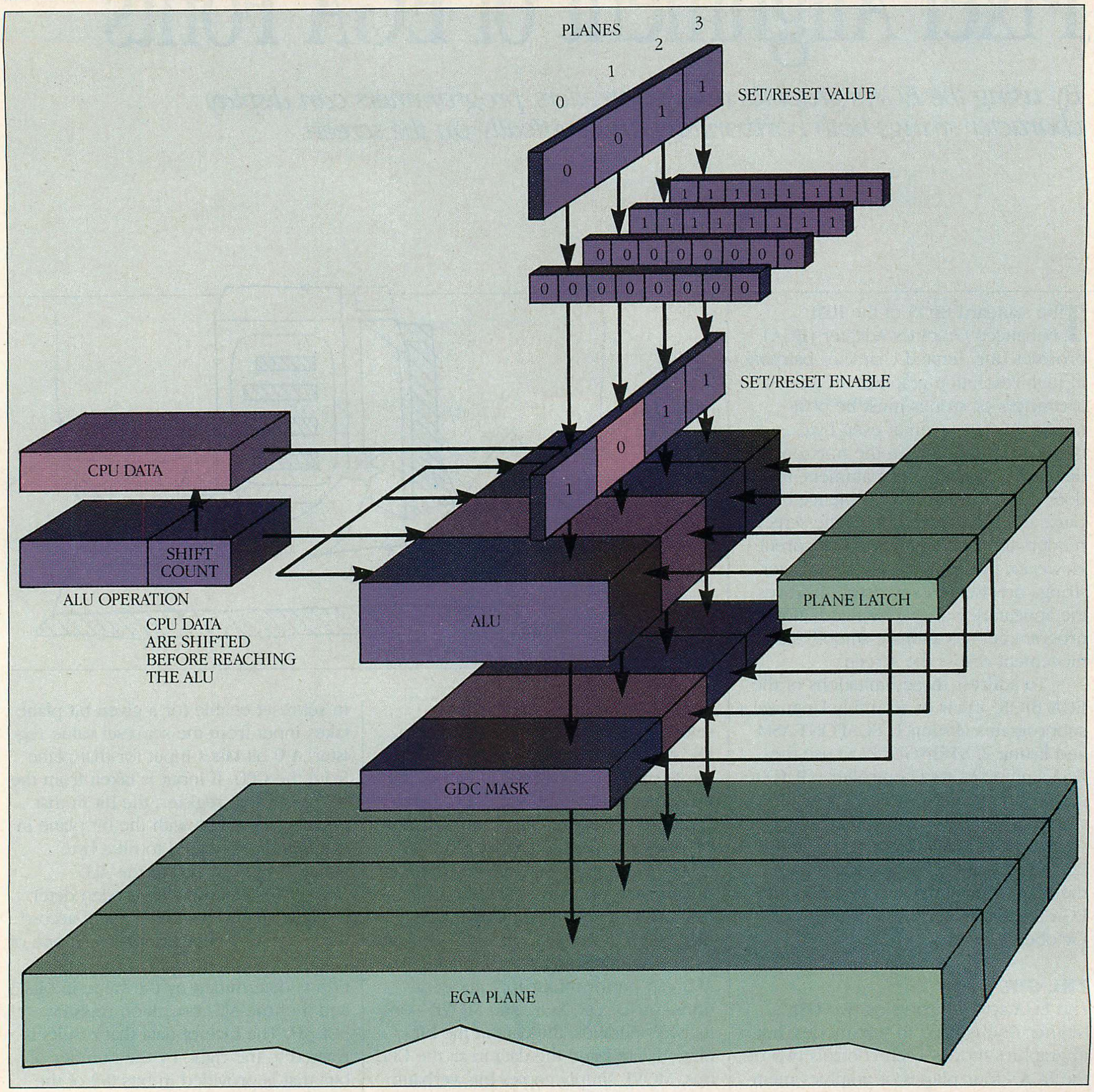
The GDC mode register at 3CF.5H defines three writing modes for sending data into the bit planes, but only one of those modes, writing mode 0, is used in the code examples presented here. In writing mode 0, one of the ALU's inputs is always the data from the bit plane latches; the other input, however, may be selected from either the CPU data or data from the set/reset value register (3CF.0H). The set/reset enable register (3CF.1H) dictates the selection.

Bits 0-3 of both the set/reset enable and set/reset value registers map to EGA bit planes 0-3, respectively. A 1 bit in set/reset enable for a given bit plane takes input from the set/reset value register. A 0 bit takes input for that plane from the CPU. If input is taken from the set/reset value register, the bit in that register associated with the bit plane in question is expanded to fill a byte, which is then passed to the ALU.

Once the inputs have been determined, the ALU combines them according to the preset operation code, one of AND, OR, XOR, or MOVE. This operation is determined by the value in bits 3 and 4 of the ALU operation register, 3CF.3H. The byte of data that results is rotated to the right, by the number of bits that is provided in bits 0-2 of the ALU operation register.

The ALU's work is then finished. Its output byte is passed on to the GDC mask operation, (figure 3). During the mask operation, the bits of the ALU result are written into the graphics RAM bit planes. Figure 3 shows all four bit planes in parallel and shows all eight rows of an 8-by-8 character for clarity. In operation, only one row is acted upon at a time, and eight separate iterations are required to write the entire character pattern into the bit planes. Keep in mind that only the top row in each set of figure 3's planes is taking part in the mask operation.

FIGURE 1: *The GDC on the EGA*



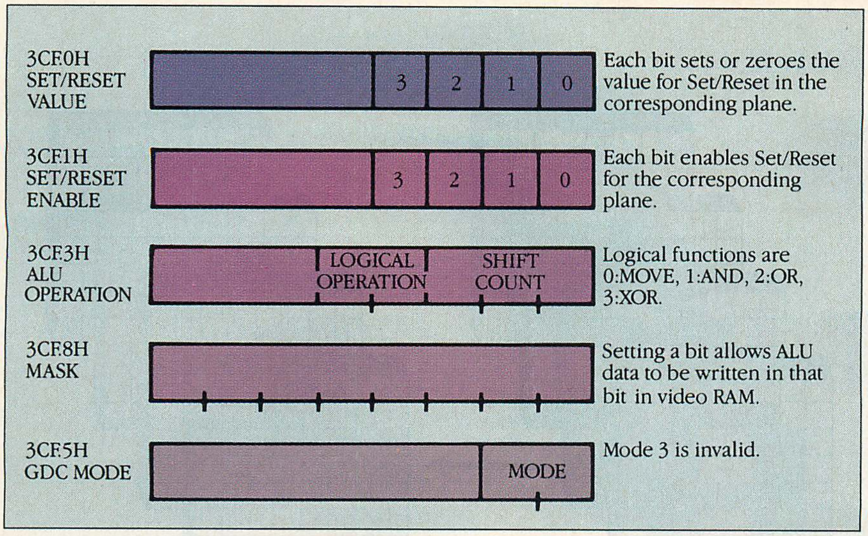
The set/reset enable register acts as a switch, selecting between CPU data and data originating in the set/reset value register. The selected data and the data from the EGA plane latches become the two inputs to the ALU for the set/reset operation in figure 3. When a shift count is specified, CPU data are shifted by a hardware shifter before being applied to the ALU.

In the mask operation, data from the ALU, which should be considered foreground data, is combined with data already in the bit planes, comprising the background. The GDC mask register (3CF.8H) determines whether a given bit in each byte of data written to the bit planes is to be foreground or background data. If a mask bit is 1, then the corresponding bit from the ALU is written into the video RAM as foreground data. If the mask bit is 0, then the corresponding latch data bit, which originated in the bit plane, is written back to video RAM as background data.

The background data in the mask operation comes from the bit plane latches rather than the bit planes themselves; the latches are loaded only during a CPU read of the bit planes. If the background does not change, the latches do not need to be reloaded, but if the background does change between writes, the latches must be reloaded by another CPU read of the bit planes.

The power of set/reset and the GDC mask of the EGA is not apparent when focusing on a single plane of the EGA. Together, the four parallel bit planes of the EGA determine the color ultimately displayed on the screen for each pixel. By placing in set/reset the desired color of the pixels, enabling the

FIGURE 2: *Registers of the EGA's GDC*



Each of the bits 0-3 in both the set/reset enable and the set/reset value registers is assigned to one of the four EGA planes. The other four bits are ignored.

set/reset operation for all bit planes, and setting the mask register to the byte value to paint, one CPU data write will paint up to eight pixels while keeping the background intact. This is precisely the technique that EGAFONT.ASM (listing 1) uses to paint in characters.

EGA BIOS FONTS

When dealing with the display of graphics characters in a graphics mode, it is often helpful to distinguish between the extended ASCII character codes, which are numbers in the range 0-255, and the *glyphs*, or pixel patterns, which represent these characters on the screen. A given ASCII character, such as *A*, may correspond to several glyphs if the character may be painted in any of several different directions.

The EGA BIOS stores two fonts on the ROM chip. One is an 8-by-14 font, and the other is an 8-by-8 font that is identical to the font used in the CGA. Each glyph is 8 pixels wide. The size, or *points*, of the font is either 8 or 14. The BIOS function call with AH = 11H (character generator routine), AL = 30H (information), and BH = 2 or 3 returns the pointer in ES:BP to the 8-by-14 (BH = 2), or the 8-by-8 (BH = 3) font table. Each glyph is laid out as a series of bytes representing rows from the top to the bottom at ascending memory addresses. Each byte in the font is a bit map of one row of a glyph, with one bit per pixel. Accessing an individual glyph in the font table is performed by multiplying the character's ASCII code by the font's point size. The resultant offset is added to the pointer value returned by the BIOS function call.

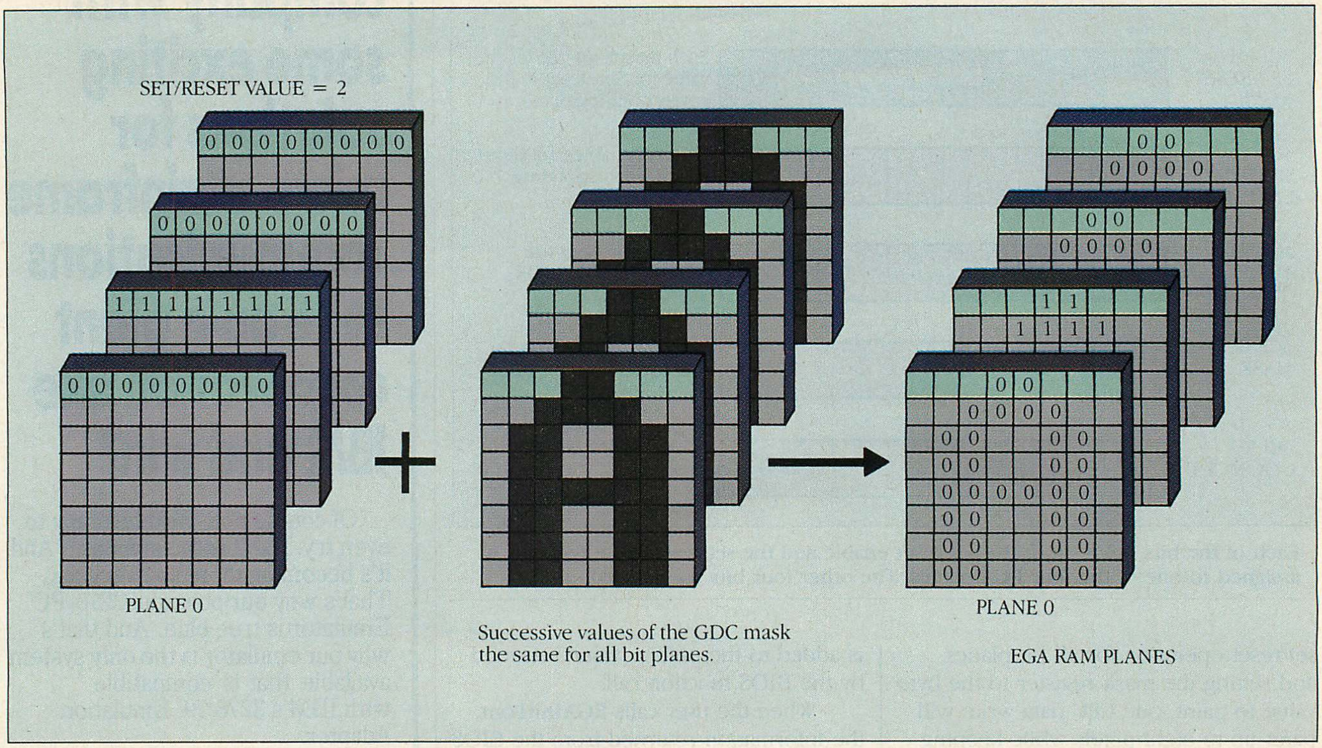
When the user calls **EGAInitFont**, the information returned from the BIOS is stored into an array of font records. Each font record keeps the width and points of one font and a pointer to the start of the font.

HORIZONTAL PAINTING

Painting a horizontal character into EGA RAM is a straightforward procedure. Figure 4 illustrates the sequence of operations. EGAFONT.ASM calculates the byte address in the display RAM where the glyph is to be placed from the *X Y* parameters supplied by the caller. The offset of the leftmost pixel of the glyph within the byte is given by the low 3 bits of the *X* coordinate. This offset specifies the number of bits by which the byte must be rotated to the right to align the left hand edge of the glyph with the byte boundary. In addition, the offset is used to index into the mask table to select the mask for isolating the left and right portions of the rotated glyph. Special techniques are required to use the mask tables from Turbo Pascal external machine code; these are explained below.

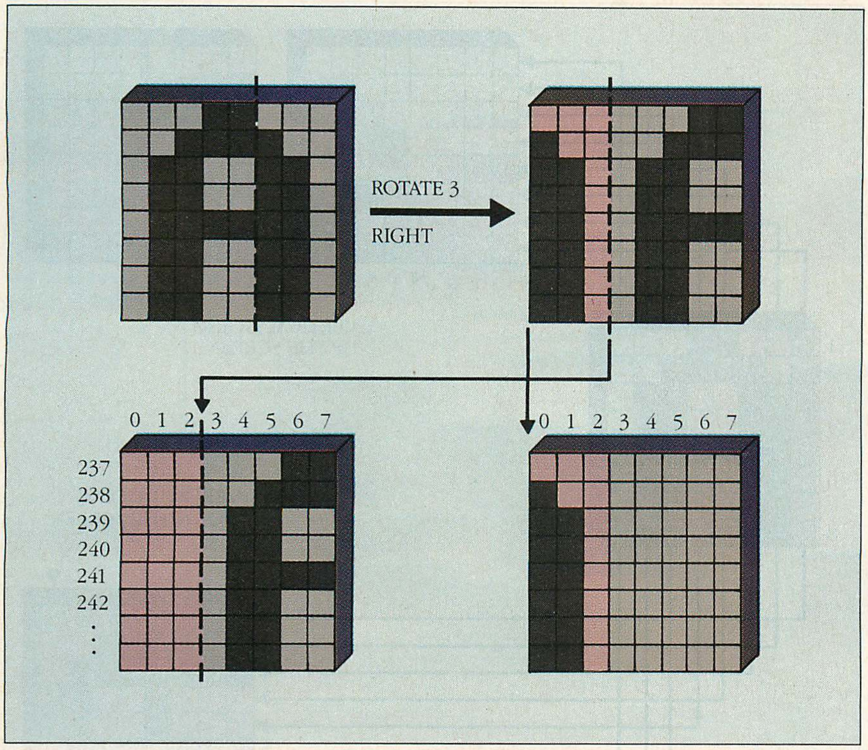
The actual horizontal painting of each byte of the glyph is performed by the subroutine **fbhor** within EGAFONT. Writing a glyph to screen memory as done by EGAFONT is a transparent operation in that the background is not changed. Each glyph is painted to the screen by way of a loop that calls **fbhor** once for each pixel row of the font in

FIGURE 3: *The GDC Mask Operation*



Glyph background information resides in the plane latches. The glyph is described in the GDC mask, which is the same for all four EGA planes. Foreground color information is applied through the set/reset value register in this example. Foreground color also could be applied as CPU data on a plane-by-plane basis by altering the bit values in the set/reset enable register. Only one glyph row is written to the planes in a single set/reset operation; the entire glyph is painted with a loop.

FIGURE 4: *Pixel-aligning a Character Glyph*



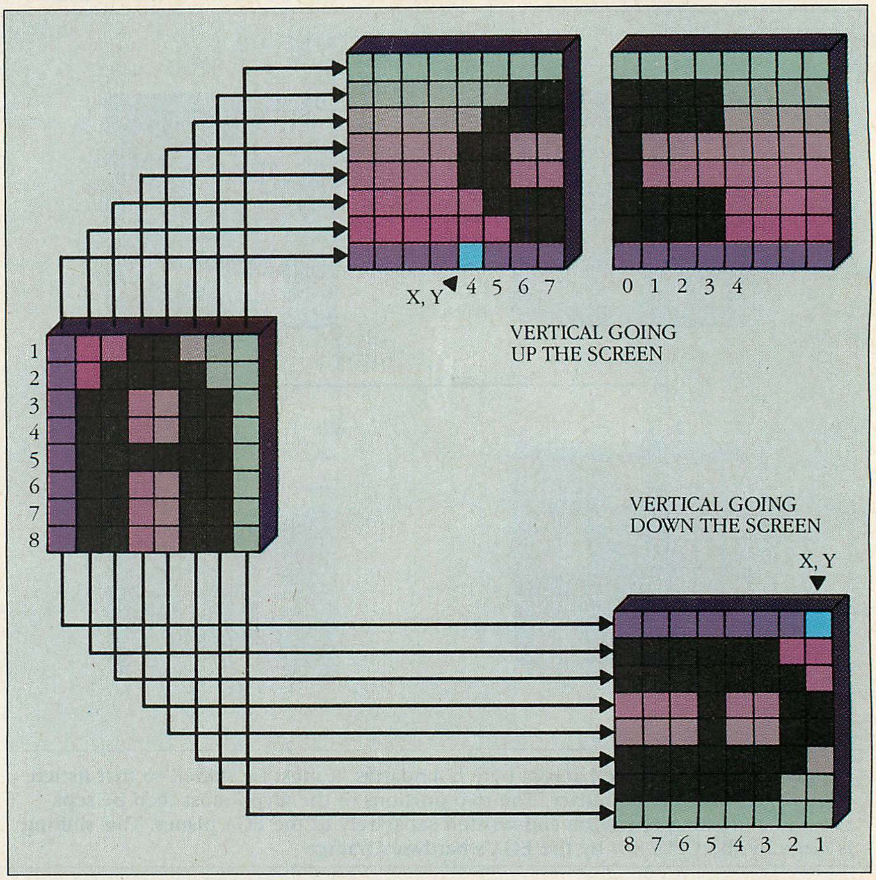
If a glyph must be painted across byte boundaries, it must be shifted so that its left edge aligns with the boundary. The two portions of the glyph must then be separated in a masking operation and written separately to the EGA planes. This shifting is done by the CPU, *not* by the EGA's hardware shifter.

use, up to the font point size. Rows of font data are passed to **fbhor** in DX. **Fbhor** rotates the font data byte to the right by the same number of bits as the pixel position of the glyph is offset from an even byte boundary.

After rotation, the glyph row is divided into two sections that must be written separately into adjacent bytes in EGA RAM. The left portion is isolated by a logical AND with a value chosen from the in-line table **mask1** with the pixel offset acting as array index.

The isolated left portion is then placed into the GDC's mask register, and the color value is placed into the set/reset value register. Next the CPU reads in the destination byte of the left portion of the glyph, loading the GDC latches with the background graphics data. Finally, in a single operation, the CPU performs a write operation to RAM, and the GDC paints the left portion of the glyph row (see figure 3). **Fbhor** increments the destination address and repeats the operation for the right portion of the glyph row before returning to the main string painting loop that updates the destination address to reflect the next scan line where the next glyph row is to placed. This process is repeated for the number of rows in the

FIGURE 5: *Painting Vertical Characters*



Glyphs to be written vertically must be rotated by the CPU and then painted to the screen by the same process shown in figure 4. Byte-aligned glyphs may be painted to the screen in one operation, as shown in the lower rotation.

font, until the entire glyph has been painted to the screen.

VERTICAL PAINTING

Because the EGA fonts are organized as a series of horizontal lines, no shortcuts are apparent for painting a glyph described by a horizontal font into a vertical box. When writing vertically, EGAFONT must set the pixels individually for each row of the font, transforming the pixels from a horizontal to a vertical orientation as it goes. This transformation is shown in figure 5. The routine that paints font information to the screen is **fbvert**.

When painting in a horizontal direction, the parameters *X* and *Y* specify the upper left corner of the first glyph in the painted string. Painting vertically in an upward or downward direction raises the question of which corner of the glyph is being specified by *X* and *Y*. EGAFONT follows the rule that *X* and *Y* specify the upper left corner of the first glyph, *from its own vantage point*. Hence, writing vertically in a downward direction makes *X* and *Y* specify the upper *right* corner of the vertical rectangle occupied by the written string, although the upper right corner of the rectangle is the upper *left* corner of the first glyph in a vertically written string. Note the marked positions of *X* and *Y* for the rotated glyphs in figure 5.

Fbvert paints vertical glyphs in both directions. The difference in operation between the two directions lies only in whether the address pointers are incremented or decremented. When drawing a glyph down the screen, each succeeding horizontal pixel is one scan line lower on the screen, at an increasing line address. When painting up the screen, each succeeding pixel is written at a decreasing line address. Similarly, the writing direction also dictates whether the pixel offset is incremented or decremented for each subsequent row of the glyph. When painting vertical glyphs in a downward direction, each row of the glyph is painted to the left of the previous row, at a lower pixel offset. When painting vertically in an

upward direction, successive rows are placed to the right of previous rows at higher pixel offsets.

THE PROGRAMS

STRINGER.PAS (listing 2) is a Turbo Pascal program that demonstrates the calling syntax for the routines in EGAFONT.ASM (listing 1). Calling the routines in EGAFONT from Turbo Pascal presents some special challenges. Turbo Pascal loads external machine code subprograms into the code segment wherever they happen to fall within the code generated from the larger Pascal program. Therefore, the external subprogram never knows its own location. This is not a problem from a code standpoint, because well-behaved 8086 machine code is fully relocatable. However, if in-line tables are assembled into an external subprogram for its use, the subprogram has no direct means of addressing the in-line tables.

The trick employed by EGAFONT to locate its own tables requires some explanation. Near the beginning of the executable code in EGAFONT is a dummy procedure, **dost2**, that contains no code. It exists only to provide a destination for a near (16-bit) CALL opcode. After the caller's DS and BP values are pushed onto the stack, a CALL is made to dummy procedure **dost2**. Because **dost2** immediately follows the CALL opcode, no significant change occurs in the order that instructions are executed. In executing the CALL, the CPU pushes the return address onto the stack. This address, which is a 16-bit offset into the code segment, corresponds to the label **dost3** and is immediately popped off the stack into AX. By subtracting the assembler-generated value of the *label* **dost3** (which is the offset of **dost3** from the first byte of generated code in the external subprogram) from the CPU—determined offset of **dost3** into the code segment, the offset of the first byte of the subprogram into the code segment is generated and stored on the stack in variable **csx**. By adding this value to the assembler-generated offset of the in-line tables, the true address of the tables can be generated at runtime.

Font information is maintained in a font table in the Pascal data area rather than within the machine code subprograms. The structure of the font descriptions contained in the font table is defined both in EGAFONT beginning at label **fontptr** and in STRINGER as the record type **fontrecord**. The font records themselves must be filled with the necessary font information before they are used. **EGAinitFont** accomplishes the initialization of font records.

EGAstring must be passed a font, the starting location of the upper left hand corner of the first glyph (from its own perspective, as explained above), the direction in which the string is to be written, the desired color, and the operation to be performed with the pixel data. The ordering and types of these parameters is documented in the listing of STRINGER.PAS.

STRINGER.PAS as given operates in EGA mode 16, 640 by 350 color. Users who wish to run on the EGA's 640-by-350 monochrome mode need only change the **m** parameter to the procedure **SetMode** to 15.

Understanding the operation of the EGA's Graphics Data Controller is not necessary to use the software presented here. However, the EGA is a classic example of knowledge equating to power; the more programmers understand the labyrinthine facets of the EGA, the better they will be equipped to tap its considerable abilities.

John T. Cockerham, M.D., is a cardiologist at the Children's Hospital in Boston and is on the faculty of the Harvard Medical School.

LISTING 1: EGAFONT.ASM

```
        page    80,132
        title   egafont -- ega font routines for Turbo Pascal
;
;       2 entry points
;       [0]     1. EGAstring(s : string; x, y, color, direction:
;                       integer; VAR f: fontrecord);
;       [3]     2. EGAinitfont(f: fontarray);
;
;       Because this runs under Turbo Pascal, no direct references
;       are made to the code segment. However registers are set up to
;       provide access to assembled tables when needed.
;               John T. Cockerham, November 1986
;       Font table layout
fontptr         equ     0       ;pointer to the actual font
fonthit         equ     4       ;height of characters
ftype           equ     6       ;type of font; 0=fixed
fwidth          equ     8       ;width of characters
FontTbSize      equ     10
;
videoio         equ     10H     ;BIOS interrupt vector
FontInfo        equ     1130H   ;Font Information Request code
StdFont         equ     0200H   ;Standard Font Info Code
DblFont         equ     0300H   ;Double Dot Info Code
GDCSet          equ     00H     ;GDC set/reset register
GDCEnab         equ     01H     ;GDC enable set/reset
GDCAlu          equ     03H     ;GDC Alu operation and shift
GDCMask         equ     08H     ;GDC bit mask
GDC             equ     03CEH   ;The GDC data register pair
;
FontWidth       equ     8       ;The width of all fonts is 8
Horiz           equ     0       ;Horizontal directions constant
Vert_Up         equ     1       ;Vertical up going direction
ScreenWidth     equ     80      ;Screen is 80 columns wide
;
;       stack layout for string and character calls
;
stx     equ     [bp+20]
x0      equ     word ptr [bp+18]
y0      equ     word ptr [bp+16]
color   equ     word ptr [bp+14]
direct  equ     word ptr [bp+12]
op      equ     word ptr [bp+10]
font    equ     dword ptr [bp+6]
retx    equ     word ptr [bp+4]
oldds   equ     word ptr [bp+2]
oldbp   equ     word ptr [bp]
x1      equ     word ptr [bp-2]
y1      equ     word ptr [bp-4]
x2      equ     word ptr [bp-6]
y2      equ     word ptr [bp-8]
csx     equ     word ptr [bp-10]
pts     equ     word ptr [bp-12]
fp      equ     [bp-16]                 ;address pointer dd here
j       equ     word ptr [bp-18]
b1      equ     word ptr [bp-20]
b2      equ     word ptr [bp-22]
stpt    equ     word ptr [bp-24]
c1      equ     word ptr [bp-26]
;
;       entry points
;
egafont segment 'code'
        assume  cs:egafont,es:nothing,ds:nothing
        jmp     dostr1
        jmp     initf1
        db      'EGAFONT'               ;So it can be found
;
;mask1 is the masks for the left byte
;bittab is the bit table for setting dots
;
mask1   db      0ffh, 07fh, 03fh, 01fh, 00fh, 007h, 003h, 001h
bittab  db      080h, 040h, 020h, 010h, 008h, 004h, 002h, 001h
;
;       Do string
;
dostr   proc    near
dostr1: push    ds
```

```
        push    bp              ;set up the stack
        mov     bp,sp           ;new stack pointer
        sub     sp,30           ;carve out space on the stack
        call    dost2           ;get offset into code segment
dost2   proc    near
dost2   endp                    ;dummy procedure segment
dost3:  pop     ax              ;this is our return address
        sub     ax,offset dost3 ;now we have start of the segment
        mov     csx,ax          ;in case we need it
        mov     stpt,0          ;this is our string pointer
str1:
        inc     stpt            ;top of character loop
        les     bx,stx          ;get the string address
        mov     al,es:[bx]      ;this is the length of the string
        xor     ah,ah           ;zap the high byte
        cmp     stpt,ax         ;look at where we are in the string
        jbe     strx1           ;all done?
        jmp     strxt
strx1:  add     bx,stpt         ;this is the character
        mov     al,es:[bx]      ;
        xor     ah,ah           ;zot the byte
        mov     c1,ax           ;the character is in hand
        les     bx,font         ;get the font pointer
        mov     ax,es:fonthit[bx]
        mov     pts,ax          ;height of characters
;
;       here calculate the font pointer
;
        mul     c1              ;this makes the offset
        lds     si,es:fontptr[bx]; this is the start of the font
        add     si,ax           ;this is the start of the character
        mov     fp,si
        mov     fp[2],ds        ;save the point for a moment
;
;       this is the main painting loop
;
        mov     j,1             ;start on the 1 line of the font
dost6:  mov     ax,x0
        mov     x1,ax           ;p1 := p0
        mov     ax,y0
        mov     y1,ax
dost7:  lds     si,dword ptr fp ;get the font point
        inc     word ptr fp     ;move the font point
        mov     dl,[si]         ;this is the actual font byte
        xor     dh,dh           ;clean up the high byte
;
        mov     ax,direct       ;branch on direction
        cmp     ax,Horiz        ;handle the regular case
        jne     dostup
        call    fbhor           ;horizontal painting
        inc     y0              ;bump for the next "line"
        jmp     short dostlnx
dostup: call    fbvert
        mov     ax,direct       ;update the point the next font line
        cmp     ax,Vert_Up      ;this is the up direction
        jne     dost11
        inc     x0
        jmp     short dostlnx
dost11: dec     x0
dostlnx:
        inc     word ptr j      ;j is the font pointer
        mov     ax,j            ;get the pointer for comparison
        cmp     ax,pts          ;another point?
        ja      dostx           ;yes again
        jmp     dost6
;
;       move the pointer to the next position in the string
;
dostx:  mov     ax,direct
        mov     bx,FontWidth
        mov     cx,pts
        cmp     ax,Horiz        ;check the direction move accordingly
        jne     dost13
        add     x0,bx           ;move across the screen
        sub     y0,cx           ;and to the top of the character box
        jmp     str1
dost13: cmp     ax,Vert_Up      ;this is the up direction
        jne     dost14
        sub     y0,bx           ;move up the screen
```

```
        sub     x0,cx           ;and to the top of the char box
        jmp     str1            ;another character
dost14: add     y0,bx           ;Vertical Down default
        add     x0,cx           ;the next box is down the screen
        jmp     str1            ;get the next character
;
;       clean up and exit
;
strxt:  mov     sp,bp           ;dissolve the stack
        pop     bp
        pop     ds
        ret     18              ;drop 18 bytes off the stack
dostr   endp
;
;       passed one pointer to the font information array
;
farray  equ     dword ptr [bp+4]
initf   proc    near
initf1:
        push    bp
        mov     bp,sp           ;stack preamble
;       get the first font information
        push    bp              ;Bios will clobber our bp
        mov     ax,FontInfo     ;information request
        mov     bx,StdFont      ;on the 8 by 14 font
        int     videoio         ;
        mov     ax,bp           ;get the returned bp pointer
        pop     bp              ;es:ax now has the font address
        lds     di,farray       ;ds:di points to start of the array
        mov     fontptr[di],ax          ;the offset
        mov     fontptr[di+2],es        ;and the segment
        mov     word ptr fonthit[di],14 ;this is the size in points
        mov     word ptr ftype[di],0    ;this is a fixed font
        mov     word ptr fwidth[di],8   ;and it is 8 pixels wide
;       get the double dot font
        push    bp              ;save the bp
        mov     ax,FontInfo     ;request information
```

```
        mov     bx,DblFont      ;on the double dot font
        int     videoio         ;ask for it from the bios
        mov     ax,bp           ;get the pointers
        pop     bp              ;and recover bp
        lds     di,farray       ;get the array pointer
        add     di,FontTbSize   ;move to the next entry in the array
        mov     fontptr[di],ax  ;the offset
        mov     fontptr[di+2],es;and the segment
        mov     word ptr fonthit[di],8  ;this is the size in points
        mov     word ptr ftype[di],0    ;this is a fixed font
        mov     word ptr fwidth[di],8   ;and it is 8 pixels wide
        pop     bp
        ret     4               ;drop 4 bytes off of the stack
initf   endp
;
;       paint a horizontal byte
;               dx = font byte
fbhor   proc    near
        mov     ax,x1           ;calculate the various offsets
        and     ax,07h          ;the offset into the bitstring
        mov     si,ax           ;and get set to index
        mov     cx,ax
        ror     dl,cl           ;this rotates it
        xor     dh,dh           ;for security
;
        add     si,csx          ;this is the cseg offset
        mov     al,cs:Mask1[si] ;get the particular mask byte
        mov     cx,ax
        and     cx,dx           ;this is one form of the character
        mov     b1,cx           ;the left portion
        not     ax
        and     ax,dx           ;this is the right portion
        mov     b2,ax
;
        mov     ax,x1           ;get set to calculate the EGA address
        mov     x2,ax           ;from points x2 and y2
        mov     ax,y1           ;in the stack
        mov     y2,ax
        call    egacalc         ;get es:di set to the EGA buffer
        mov     ax,color        ;fix the set/reset mechanism
        mov     bx,0fh          ;in all planes to the color
        call    setreset        ;
        mov     ax,op           ;now get the ALU all set up
        call    egaalu          ;done
;
;       pixel string straddles two bytes
;
        mov     ax,b1           ;first mask
        call    egamask
        mov     al,es:[di]      ;get the byte latched in
        mov     es:[di],al      ;latches and set reset do all
        inc     di              ;move to the next byte
        mov     ax,b2
        call    egamask         ;this is the next byte
        mov     al,es:[di]
        mov     es:[di],al      ;all done with both bytes
;
;       all done clean up
;
        mov     ax,0ffH         ;reset the mask
        call    egamask
        xor     ax,ax
        xor     bx,bx
        call    setreset
        xor     ax,ax
        call    egaalu          ;reset the hardware
        ret
fbhor   endp
;
;       Paint Vertical Byte depends on point access routines
;       paint the byte at point p1
;
fbvert  proc    near
        mov     ax,x1           ;make copy of the point
        mov     x2,ax
        mov     ax,y1
```

```
        add     ax,FontWidth    ;start off
        mov     y2,ax           ;from the character
        mov     cx,FontWidth    ;get set to loop
        mov     bx,080H         ;start from the left edge of the byte
fbv1:   mov     ax,dx           ;get the font byte
        and     ax,bx           ;is the bit set
        jz      fbv2            ;no then skip this drawing
        push    dx
        push    bx
        push    cx
        call    dot             ;draw the dot at point #2
        pop     cx
        pop     bx              ;the dot is drawn
        pop     dx
fbv2:
        shr     bx,1            ;look at the next bit
        cmp     direct,Vert_Up  ;do we bump or drop to the next point
        jnz     fbv3
        dec     y2              ;this is painting up
        jmp     short fbv4
fbv3:   inc     y2
fbv4:   loop    fbv1
        ret
fbvert  endp
;
;       Set EGA GDC Bitmask
;               ax = mask value
egamask proc    near
        mov     ah,al           ;get value in high byte
        mov     al,GDCMask      ;set up the IO instruction
        mov     dx,GDC
        out     dx,ax           ;put it out
        ret
egamask endp
;
;       Set EGA set reset registers
;               ax = value to fill; bx = planes
setreset proc   near
        mov     ah,al           ;get the value in the right place
        mov     al,GDCSet       ;point to the GDC set register
        mov     dx,GDC          ;set up IO instruction
        out     dx,ax           ;first half of instruction
        mov     ah,bl           ;these are the enable bits
        mov     al,GDCEnab      ;this in the enable register
        out     dx,ax           ;talk to the device
        ret
setreset endp
;
;       Set EGA GDC Alu operation and shift
;
egaalu  proc    near
        mov     ah,al           ;get value in high byte
        mov     al,GDCAlu       ;set up the IO instruction
        mov     dx,GDC
        out     dx,ax           ;put it out
        ret
egaalu  endp
;
;       calculate EGA address
;               x2, y2 in the stack
egacalc proc    near
        mov     ax,y2
        mov     cx,ScreenWidth
        mul     cx              ;get the offset
        mov     bx,x2           ;now figure offset within the row
        mov     cx,3
        shr     bx,cl           ;strip down to a byte address
        add     ax,bx
        mov     di,ax           ;di is now set
        mov     ax,0a000H       ;this is the screen segment
        mov     es,ax
        nop
        ret
egacalc endp
;
;       dot -- draw a dot
;
dot     proc    near
        call    egacalc         ;get es:di to point to the byte
        mov     ax,x2           ;figure out the bit offset
        and     ax,07H          ;this is the offset in the byte
        mov     bx,csx          ;get set to address ourselves
        add     bx,ax           ;now point within the bittab table
        mov     ah,cs:bittab[bx];get the mask value in ax
        mov     al,GDCMask      ;isolate to the bit in question
        mov     dx,GDC          ;talk to the GDC
        out     dx,ax           ;the mask is set
        mov     ax,op           ;set up the operation
        mov     ah,al           ;get to the upper byte
        mov     al,GDCAlu       ;this is the ALU
        out     dx,ax           ;done setting operation
        mov     ax,color        ;this is the color
        mov     bx,0FH          ;into set/reset
        call    setreset
        mov     ch,es:[di]      ;get the ram byte latched in
        mov     byte ptr es:[di],0FFH;set reset fills in the color
        xor     ax,ax           ;turn off the ALU
        call    egaalu
        xor     ax,ax           ;and set reset
        xor     bx,bx
        call    setreset
        mov     ax,0ffh         ;now turn on the bitmap
        call    egamask
        ret                     ;all done
dot     endp
egafont ends
        end
```

LISTING 2: STRINGER.PAS

```
{ This program test the off-byte character painting routines }
{ The external subprogram EGAFONT.BIN is required}
{          John T. Cockerham, November 1986 }

const movop   : integer      = 0;
```

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```
      xorop   : integer       = $18;
      andop   : integer       = $8;
      orop    : integer       = $10;
      screenwidth             = 80;
      Horizontal : integer    = 0;
      VerticalUp : integer    = 1;
      VerticalDown : integer  = 2;
      Standard                = 0; { Refers to the 8x14 font}
      DoubleDot               = 1; { Double dot 8x8 font}
      cgreen : integer        = 2;
      cblue  : integer        = 1;
      cred   : integer        = 4;
      cyellow: integer        =14;
      cbrown : integer        = 6;

type  fontrecord = record
         fontptr : ^integer;
         points,fonttype,fontwidth : integer;
      end;
      Fontarray = array [0..2] of fontrecord;
      p__reg_rec = record case integer of
                  1:(ax,bx,cx,dx,bp,si,di,ds,es,flags: integer);
                  2:(al,ah,bl,bh,cl,ch,dl,dh: byte);
                  end;

var   bitmasks : array[0..7] of integer;
      EGAfonts : fontarray;

procedure SetMode(m: integer);                  { mode in [0..15] }
var  p__reg :  p__reg_rec;
begin
   if not(m in [0..$10]) then m := 0;
   with p__reg do begin  ah := $00; al := m; end;  { with }
   Intr($10, p__reg);
end;

{ The external subprogram gets loaded here}
procedure EGAfont;                        external 'EGAfont.bin';

procedure EGAstring(var str; x, y, color, direct, op :
                    integer; var font);   external EGAfont[0];
    { direc : [Horizontal .. VerticalDown]
      color : [0..15] from palette }

procedure EGAinitfont( var f : fontarray); external EGAfont[3];

var x, y, i : integer;
    st, st1 : string[80];
begin
  st := 'PC Tech Journal';
  st1 := 'Pausing... strike return to continue';
  {Turn on high resolution video mode, on mono systems use mode 15}
  setmode(16);
  EGAinitfont(EGAfonts); {initialize the font data objects}
  i := 0;
  while i < 36 do
    begin
      EGAstring(st,100+i,100+i,cbrown, Horizontal,movop,EGAfonts[Standard]);
      EGAstring(st,101+i,101+i,cred,   Horizontal,movop,EGAfonts[Standard]);
      EGAstring(st,102+i,102+i,cblue,  Horizontal,movop,EGAfonts[Standard]);
      EGAstring(st,103+i,103+i,cbrown, Horizontal,movop,EGAfonts[Standard]);
      EGAstring(st,104+i,104+i,cyellow,Horizontal,movop,EGAfonts[Standard]);
      EGAstring(st,105+i,105+i,cgreen, Horizontal,movop,EGAfonts[Standard]);
      i := i + 6;
    end;
  readln;
  i := 0;
  while i < 36 do
    begin
      EGAstring(st1,100,300,cred,Horizontal,xorop,EGAFonts[DoubleDot]);
      EGAstring(st,100,100,cblue,Horizontal,xorop,egafonts[Standard]);
      EGAstring(st,200,250,cbrown,VerticalUp,xorop,egafonts[Standard]);
      EGAstring(st,300,100,cyellow,VerticalDown,xorop,egafonts[Standard]);
      EGAstring(st1,100,300,cred,Horizontal,movop,EGAFonts[DoubleDot]);
      i := i +6
    end
  readln;
  EGAstring(st1,100,300,cred,Horizontal,xorop,EGAFonts[DoubleDot]);
  TextMode;
end.
```

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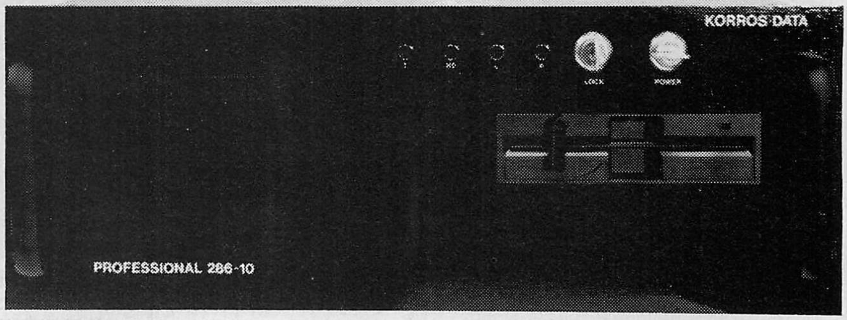

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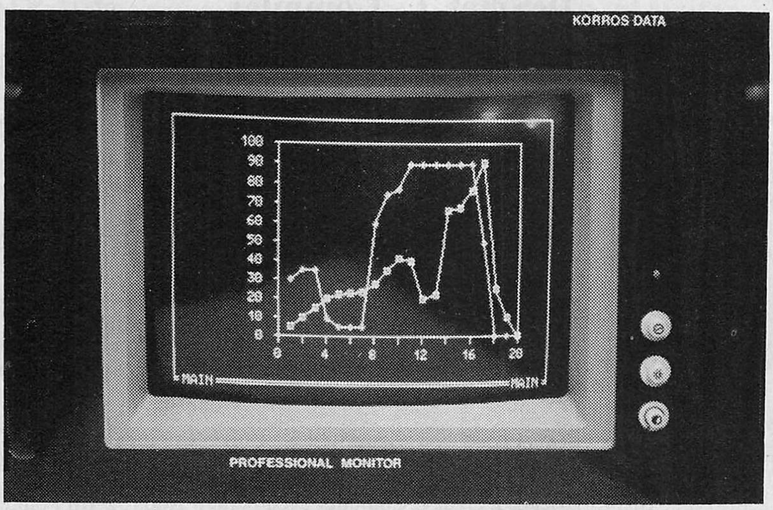

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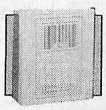

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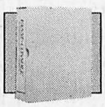

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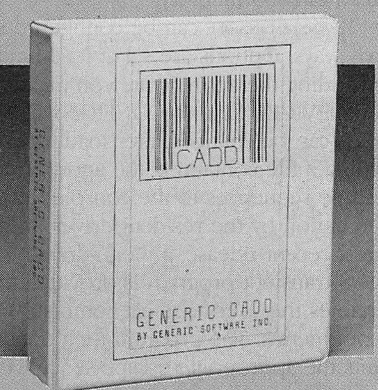

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Generic Software's Generic CADD package brings the low-budget CAD user the functionality of much more expensive systems for under $100. The term CADD (computer-aided drafting and *design*) may not be entirely deserved, but the price belies the power of the program.

Generic CADD resembles early versions of AutoDesk's AutoCAD. The screen layout is very similar, with coordinates displayed on the top line, a screen menu along the right edge of the screen, and three lines of text at the bottom. Commands can be selected from the screen menu or typed in at the command prompt independently of the current screen menu. Lines can be drawn at the command prompt without entering an explicit command.

Commands are entered quickly with two-letter names. The two-letter names, however, are not very descriptive in many cases. Whereas LI is a straightforward abbreviation for the Straight Line command, YG is a rather esoteric abbreviation for Layer Change. The new user is well-advised to keep the supplied reference card handy while learning the commands.

The program provides a complete set of drawing primitives: points, lines, circles, arcs, text, rectangles, ellipses, regular polygons, and complex curves. Generic CADD also provides a facility for the creation and use of complex objects (or symbols) called *components*, which are constructed of primitives and/or other components. Objects can be assigned line-type and color properties individually, and even can be classified by layers. Generic CADD provides 255 numbered layers.

The set of editing commands is complete. Objects can be erased, moved, copied, or broken. An Object Change command can change the color and line type of an object. Objects can be selected for editing by choosing them through a window or layer.

Generic CADD's drawing world is limited in size. Experimentation revealed that the drawing world is limited in height to approximately 360,000 inches—where one database unit represents one inch. (The manual does not include those statistics.) The display shows the cursor position only to four decimal places, but the cursor moves smoothly between any point on the screen at any scale. This is a disadvantage because accurate placement between the grid snap points cannot be ensured. When the system is set up with the Hercules Graphics Card installed, setting the limits to a large value and moving the cursor past that point sends the program into outer space. The system dumps the user out of the program into DOS, and then the system has to be rebooted. With the IBM Color Graphics Adapter (CGA) installed, this problem does not occur.

Display controls and drawing aids are complete, including zoom, pan, redraw, snap to grid and to nearest point, grid, reference point and construction point display control, and layer. Units can be displayed in both metric and English units, including feet and inches, with inches present in either decimal or fractional form. Angles are shown in decimal degrees or in DD:MM:SS format. The rubber-band cursor can be toggled on and off.

Components, layers, and entire drawings can be saved and loaded, even into specified layers, if desired. Generic CADD can dump all the symbols of a drawing, placing each component into a separate file. This would be a welcome feature in many of the more expensive programs. Generic CADD also can dump an entire drawing into a batch file, creating a command script for the entire drawing that can be edited or reexecuted as a demonstration.

Hardware requirements are modest compared with more expensive CAD programs. The host must be an IBM PC, PC/XT, PC/AT, or compatible with 384KB of RAM; two diskette drives (or one diskette and one hard disk); and a supported graphics adapter and monitor combination. Optional items include an 8087 or 80287 numeric coprocessor, a plotter, and a digitizer or mouse. The program supports a variety of devices, and includes a menu-driven program for easy configuration. Supported devices range from basic items such as the CGA and the Mouse Systems PC Mouse, to such high-performance items as the Number Nine Revolution graphics controller and E-size plotters.

The documentation is complete and well organized in that it follows the standard screen menu. The manual includes a convenient reference card.

Generic CADD can be customized to a surprising degree. Screen menus are separate ASCII text files, allowing the user to modify the standard menu or to create an entirely new menu. If a digitizer is used as the pointing device, it can be configured to include up to 10

digitizer menu areas as well as the screen pointing area. Screen and digitizer menu items can contain single commands or complex command sequences. Menu items are limited to 80 characters, and menu files to 5KB. Command sequences longer than 80 characters can be created in batch files and loaded via screen or digitizer menu selections. Both menu items and batch files are limited to linear sequences of normal commands; programming constructs are not provided.

Generic CADD can also be customized with the creation of additional text fonts. New fonts are created graphically, and existing fonts can be edited.

Conspicuous by their absence, in an otherwise full-featured program, are automatic dimensioning and hatching facilities. Measuring commands are included—for distance, angles, and area—but extension lines, arrowheads, and dimension lines must be drawn piecemeal, or with a custom macro. Likewise, cross-hatching must be performed one object at a time. These features are offered in an add-on module called Auto-Dimensioning, which sells for $49.95.

One anomaly of Generic CADD is that the screen cursor and menu cursor are always on, and they track vertically. Setting the snap-to-grid on can cause the menu cursor to skip some selections if they are aligned precisely midway between two grid points. The Window Erase command is erratic; it often refuses to erase an entire screen, but the command functions properly when the window is reduced in size.

Another quirk of Generic CADD is its zoom feature. The available zoom ratio of 4-million-to-1 is nice, but the increments possible are very limited. For example, the user cannot zoom in at 80 percent. The zoom-in window must be smaller than 75 percent of the screen. Zooming out has a similar problem in that the minimum zoom out is often too much to be of use.

Using Generic CADD on the CGA is unacceptable. The text display is very coarse. It is not possible to hit all of the menu selections and the prompt line is not completely visible.

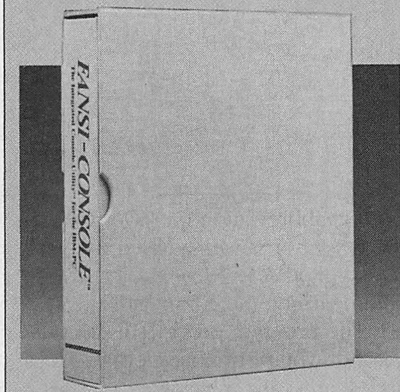
When compared with other inexpensive CAD packages, Generic CADD fares well and is worth its modest price. Although it lacks some drafting features found in more expensive programs, it is equal to most drafting requirements for the CAD student, and even includes some features missing in more expensive programs.

—VICTOR E. WRIGHT

FANSI-CONSOLE

Hersey Micro Consulting, Inc.
P.O. Box 8276
Ann Arbor, MI 48107
313/994-3259

PRICE: $75 (demo disk, $25)



CIRCLE 361 ON READER SERVICE CARD

FANSI-CONSOLE is an installable console-driver device that works with DOS 2.0 and later and runs on IBM and compatible systems. It replaces the DOS console driver as well as the screen and keyboard parts of the ROM BIOS.

Like the ANSI.SYS driver included with DOS, FANSI-CONSOLE processes ANSI X3.64 control sequences. FANSI-CONSOLE, unlike ANSI.SYS, supports a much larger subset of the standard ANSI escape sequences. Also, the product includes extensions to the standard as implemented in VT-100 terminals.

This product can speed up all screen I/O performed through DOS or BIOS calls. For example, a 520KB text file was copied to CON:. The test was run on a 4.77-MHz IBM PC, with the test file residing on a 20MB hard disk with an average access time of 85 milliseconds (ms). Without the console driver, the file took 5 minutes, 30 seconds to be displayed. After rebooting with FANSI-CONSOLE, displaying the file took 2 minutes and 48 seconds—about half the time. Similar time savings occur when running programs that do not write directly to screen memory.

The Scroll Lock key also will behave differently. Pressing it will halt the display and put the user into screen recall mode. The arrow keys then can be used to scroll through the saved screen buffer. Saved-screen information also may be written to a file. Pressing Scroll Lock again continues the previous display where it left off.

FANSI-CONSOLE increases the keyboard type-ahead buffer to 255 characters, and it also can decrease the key-repeat delay as well as increase the key-repeat rate. It offers flicker-free scrolling for many color monitors and allows the user to rearrange key definitions (including a predefined key-definition file for the Dvorak layout) and to use "sticky" Shift keys for one-finger typing. Also, the user can control the length of the sound triggered by the ASCII BEL control character and also can add an adjustable keyboard click.

FANSI-CONSOLE's memory requirements depend on which features are specified. The driver is loaded via a line in the CONFIG.SYS file:

```
DEVICE=FANSICON.DEV
```

Optional parameters can specify the features to enable and provide some control over memory usage. The screen-scroll recall buffer can be configured to use expanded memory, if available, instead of DOS memory.

FANSI-CONSOLE can be configured in two ways. Options are set at load-time by adding the appropriate commands to the DEVICE= line in CONFIG.SYS. Options can be changed after loading by typing a file containing the appropriate escape sequences to the console for interception by the resident driver. In the most recent release, a menu-driven DOS transient program is provided that enables the user to select commands from menus. The program then transmits the appropriate escape sequences to the console.

FANSI-CONSOLE can process significantly more control sequences than ANSI.SYS, which allows greater control over the screen displays. A 23KB demo file (included on the disk) provides a dazzling, on-screen display when it is typed to the screen. The file contains more than 700 lines of escape sequences and performs several tricks, including rapid horizontal and vertical scrolling within windows.

Although FANSI-CONSOLE's documentation is nicely laid out and well written, some of the explanations of the features are severely lacking—additional examples would be helpful. A list of programs and systems that are known to be compatible is provided as well as a much shorter list of those that are incompatible with FANSI-CONSOLE. The list of incompatible computers include: PC*jr*, 3270-PC, DEC Rainbow, Tandy 2000, TI Professional, and Wang PC.

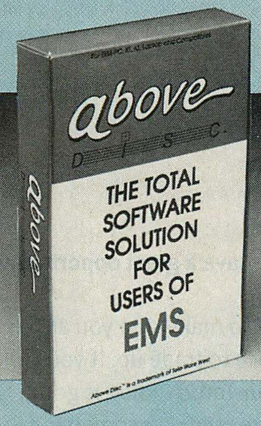
The increased display speed, faster keyboard repeat rate, and full ANSI.SYS compatibility make FANSI-CONSOLE a fine enhancement to any IBM system.

—JOHN WALKENBACH

ABOVE DISC

Tele-Ware West
18023 Skypark Circle, Suite E-2
Irvine, CA 92714
714/250-3320

PRICE: $69.95



For those who want the benefits of expanded memory without the expense of a board, Tele-Ware West produces a software product that simulates the nonreserved functions of expanded memory on a disk system or in extended memory of the IBM PC/AT. Above Disc, which conforms to the Lotus/Intel/Microsoft expanded memory specification (LIM EMS), provides access to 8MB of simulated, paged memory by implementing virtual storage.

The LIM EMS does not define hardware requirements, nor does it define how expanded memory is to be implemented. It is a software interface, just as DOS is a software interface to application programs. An application treats expanded memory in the same way it treats a file; it is a logical entity. Exactly where it exists and how it operates is of no concern to applications.

Hardware vendors typically place their 64KB page frame on some 16KB boundary. The reason for this is purely economical: it requires less address decoding circuitry. The LIM EMS says nothing about placement of the page frame; it merely defines its existence. The exact location of this frame may be known by asking the EMS driver (function 2), which returns the segment address of the paragraph boundary.

Theoretically, the page frame could be placed on any 16-byte (paragraph) boundary. This is precisely how Above Disc operates. Once it is made resident, Above Disc occupies 64KB for the page frame, plus a small amount for the expanded memory driver.

Above Disc's INSTALL program guides the user through installation by asking (1) Which is the boot drive?, (2) Which drive is to contain the swap file?, (3) How many 16KB pages are to be allocated to expanded memory?, and (4) Do you wish to update CONFIG.SYS?

Above Disc is implemented in two parts: a resident device driver, named VEM.SYS, and a resident file, named ABVDISC.COM. INSTALL copies both of these files to the boot volume and updates the CONFIG.SYS file to include VEM.SYS. The file ABVDISC.COM is used to initiate expanded memory.

Above Disc cannot support device drivers that use expanded memory. As a device driver is being initialized, it is permitted to use only DOS services for character I/O (functions 01H through 0CH). This implies that file access is not allowed, and, of course, Above Disc relies heavily on DOS files. Therefore, programs such as Quadram Corporation's XQLPT1.SYS (a printer spooler that uses expanded memory as the storage medium) cannot function.

The following benchmark tests were conducted on an AT Model 239 with 640KB of conventional memory, 1,920KB of extended memory (using American Micronics' Elephant board), 1,024KB of Intel's Above Board expanded memory, and a 30MB hard disk with a 37-millisecond (ms) average access time. In both modes, Above Disc was instructed to simulate 1,024KB of expanded memory. All tests were conducted with available versions of commercial software. All program and data files were kept on the same hard disk that contained the SWAP file.

Two tests were conducted with Lotus 1-2-3 version 2.0. Test A (see table 1) consisted of loading and calculating a spreadsheet that contained the integers 1 to 4 in cells A1..D1 and the formula 1+A1, 1+B1, etc., in cells A2..D2, continuing to cell D4999, which contained the formula 1+D4998.

Test B (see table 1) had in cells A1..A5000 the text string "This is a long line of text which will be moved and copied," and consisted of loading and then copying A1..A5000 to H1..H5000.

An additional test was conducted with DESQview version 1.21 from Quarterdeck Office Systems (see table 1), which consisted of loading five copies of BASICA into the system and measuring the amount of time required to SWAP IN a BASICA window.

Two final tests were conducted with Ready! version 1.0 from Living Videotext, Inc. Test 1 (see table 1) measured the time it took to load the program, and Test 2 (see table 1) measured the time to invoke it. While the time to invoke Ready! from Above Board memory was essentially nil; it did not take much longer to invoke the program from extended memory. The results were averaged over several trials, but, because a stopwatch was used, the results are approximate.

With the implementation of disk paging, Tele-Ware has actually created a true virtual storage mechanism. The concept of virtual memory is not new; however, its implementation on personal computers is. Virtual storage is a trade-off of performance loss for hardware dollars saved.

—GUY QUEDENS

TABLE 1: *Timed Benchmark Test Comparisons*

	ABOVE BOARD	ABOVE DISC with AT extended memory		ABOVE DISC using a disk file	
Lotus 1-2-3					
Test A					
Load	152.8	167.3	(1.1)	325.3	(2.1)
Calculate	28.6	29.1	(1.0)	38.1	(1.3)
Test B					
Load	25.1	26.7	(1.1)	42.9	(1.7)
Copy	8.1	16.1	(2.0)	113.0	(14.0)
DESQView	0.8	1.2	(1.5)	6.0	(2.2)
Ready!					
Test 1	12.5	14.3	(1.1)	18.8	(1.5)
Test 2	0.6	0.8	(1.3)	3.9	(6.5)

All times in seconds.
Numbers in parentheses represent the performance factor relative to the Above Board.

Using a disk file as expanded memory with Above Disc allows economical, if infrequent, use of very large databases without incurring any hardware expense.

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Free Enterprise

User-supported software may be an alternate route to take a program to market, but heed the warning signs along the way.

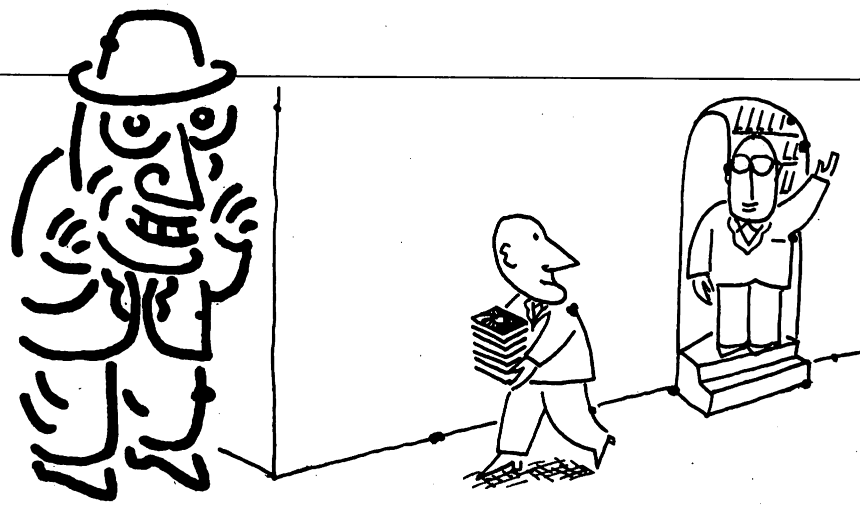


ILLUSTRATION • MACIEK ALBRECHT

Writing a commercial computer program takes significant time and effort; making a copy of a program takes very little of either. Marketing software through traditional channels is expensive. Hence the development of the marketing technique known variously as user-supported software, shareware, or Freeware. (*Freeware* is a term coined by the late Andrew Fluegelman to market programs, such as his PC-TALK, and is a trademark name. Shareware is a term used extensively by Nelson Ford in conjunction with his software-clearinghouse network in Texas. To avoid any unintended confusion or implication, the term user-supported software will be used throughout this article.)

The author of user-supported software encourages its copying and distribution at a nominal (or no) cost. Users are requested to contribute what they think is fair to the author, but are under no legal obligation to do so. A small, unscientific survey indicated that significant financial rewards from the distribution of user-supported software are not very likely, although there are several notable exceptions, such as PC-TALK and Jim Button's PC-FILE.

In the spirit of those who choose to give away their software, here are some ideas about how to do so. These ideas are general; bear in mind that the marketing of games, for example, is different from the marketing of financial-planning software.

The distribution of user-supported software should be approached in the same fashion as the distribution of software through traditional commercial channels—attention should be paid to trademark, copyright, trade secret, patent, and liability issues. The decisions on these issues should be tempered, however, by the fact that the program is being distributed without charge.

The trademark issue involves two questions: should a trademark be claimed and, if so, should it be registered. Fortunately, significant trademark protection is available for free. Simply placing the letters *TM* after the product name can establish that name as a trademark. For example, if you have a spreadsheet program called Pond Scum, your first screen should display "Pond Scum (TM) Spreadsheet Program." This establishes your claim to the trademark Pond Scum and protects you against subsequent users of the same, or a confusingly similar, mark on similar products in the geographic area in which your mark has been used commercially.

A federally registered trademark confers substantially greater protection, but the filing fee is $165, and the mark cannot be registered until it has been used in interstate commerce (for example, by a sale to someone in another state). The owner of a federally registered trademark is protected against subsequent users of the same, or a similar, mark anywhere in the United States. A trademark can be claimed by using the *TM* symbol and then registered after its commercial value is determined. There is no time limit within which a mark must be registered, but the longer you wait, the greater the chance someone else will acquire adverse rights. (Some states have an inexpensive state registration procedure that can be followed as well.)

The copyright issue also involves two questions: should the program be copyrighted and, if so, should it be registered. Under the U.S. Copyright Act, a program is automatically copyrighted as soon as it is expressed in a tangible medium, such as a source code listing or a program saved on a disk. The question really is whether or not to abandon the copyright by placing the program in the public domain. It is possible to allow certain broad public uses of a copyrighted program without placing the program in the public domain, and, in general, that is what should be done.

If you abandon the right to control copying, not only are you permitting the public at large to make copies for their own use, but also you are permitting anyone to copy and then sell your program. Do you really want a giant company to package your program in a slip binder, put their name and logo on it, and sell it for $595? While paying $595 for a program that is available elsewhere for free might seem irrational, good marketing can be very persuasive; a company that acquires a program for free and sells it for $595 can afford to spend much more for advertising than the original author.

A copyright protects not only the author's right to copy the work, but other important rights as well, including

the right to produce derivative works. This is a particularly valuable right if you are giving away an early version of a program that you hope eventually to polish into a traditional commercial product. By retaining the copyright, you can prevent competitive marketing of works that incorporate your core program; by placing your program in the public domain, you cannot.

The first suggestion, then, is to retain the copyright on the program and place in the public domain only those rights that are consistent with the reason you have chosen to allow free distribution: if you are doing it for fame, require that your name appear on the introductory screen of any program based on yours (if you expect donations, you will want to be sure that your name and address appear anyway); if you are doing it for the benefit of those people who cannot afford to pay $595, retain the sole right to sell the program (or place a limit on the price that can be charged); and, if you are doing it as a beta test of a program under development, retain the sole right to produce derivative works.

You can accomplish these objectives by placing a copyright notice on the work and then licensing the right to use the copyrighted work. Ordinarily, a copyright notice is placed on the diskette and any accompanying manuals. Because user-supported software is distributed in chain-letter fashion, it is impossible to label the distributed medium. However, the software can be labeled by displaying a copyright notice on the user's screen. The notice should be in the form "Copyright (c) 1986 Author's name. All rights reserved."

The more difficult copyright question is whether to register the work or not. Registration is conceptually simple, but it may raise difficult questions. If your program contains no trade secrets, registration is accomplished by mailing a copy of your program (with the appropriate form or forms) to the U.S. Copyright Office, along with the registration fees. Textual works are registered using *Application Form TX, Kit No. 113* (which is available by mail from the U.S. Copyright Office, Library of Congress, Washington, DC 20559, or by telephone from the 24-hour Forms Request Hotline, 202/287-9100).

Registration establishes beyond question the existence and contents of the program as of the registration date. Registration, however, creates a public record of your program. Therefore, if your work contains trade secrets, several options must be considered. The first is to forego registration. The second is to register the source code, but to delete the secret portions, sacrificing protection for the omitted portion. A third option is to register compiled code on the theory that few people can reconstruct your proprietary techniques from compiled code. The U.S. Copyright Office will accept such a filing, but will not guarantee that a valid copyright has been secured.

Registering incomplete code will generally be the preferred option and can be done in one of two ways. The traditional way is to request a special exception to the filing requirements, permitting the deposit of source code with selected lines of code blacked out. Current copyright office policy is to grant permission to file only the first and last 25 pages of source code with up to 50 percent of the lines deleted. An alternative approach is available, however. The code can be registered with whatever deletions you choose and with comments indicating where code has been omitted and, in general, what the omitted code did. This will protect the (presumably nonfunctioning) code—unlike patents, copyrights do not need to be capable of functioning. The complete program then would be protected to the extent that it constituted a derivative work of the incomplete code.

Patent protection has recently become a subject of renewed interest with respect to computer programs. Patent rights are lost if an application is not filed within one year from the first date the program is offered commercially. If there is a possibility that you may want to apply for a patent on your program at a later date, you need specific legal advice before you begin even user-supported software distribution.

Protecting your proprietary rights in the software is only half the story; personal liability is the other half. The mere fact that you are not "selling" your program commercially does not of itself insulate you from liability.

One factor in determining potential liability is whether or not the Uniform Commercial Code (UCC) applies to user-supported software transactions. The UCC is a core of statutory provisions that forms the basis of the commercial law in most states. Among its provisions are the creation of certain implied warranties, such as those of merchantability and fitness for purpose. Shrink-wrapped licenses disclaim such warranties, because, in the absence of

an effective disclaimer, the UCC gives buyers remedies if the goods they purchase do not conform either to the customary definition of what they purport to be or to the specific needs of the customer (that is, if the seller is aware of those needs and his expertise has been relied upon to choose appropriate goods). User-supported software distribution arguably is not within that particular scope because the acquiring party has no obligation to make any payment to the author of the program.

I am not aware of any judicial determination of whether user-supported software is covered by the UCC and it is unlikely that you will want to be the defendant in the first case to consider the question. Therefore, you can limit your exposure in the same manner that traditional sellers of software do: with a license agreement. The concept of licensed user-supported software may seem inconsistent at first. Let me sketch out a method of licensing user-supported software that seems to be compatible with the notions of user-supported software distribution.

To begin with, the user-supported software is copyrighted for the reasons described above. The first screen of any independently accessible module of the software (including README files, disk-based manuals, and, of course, the program itself) displays the copyright notice and a statement that the program is licensed, at no charge, subject to the following conditions:

1. The program may be copied ad lib provided that the author's copyright notice and disclaimers of warranty are reproduced in full.
2. Copies of the program may not be sold for more than $10 each.
3. The program is supplied as-is and the author disclaims all warranties, expressed or implied, including, without limitation, the warranties of merchantability and the warranties of fitness for any purpose.
4. The author's name and address, a mechanism for registration, a statement of an appropriate payment (if desired), and (if appropriate) an offer of updates upon receipt of registration should be included.

The registration procedure should consist of sending the author a statement such as "Please register me as an owner of a copy of your XYZ user-supported software program. I agree to your disclaimer of all warranties and your restrictions on copying." Having a signed statement eliminates the concern that shrink-wrapped licenses might not be enforceable. If you receive a check but no acknowledgment, you probably have an enforceable agreement. Keep a copy of the check as evidence.

One final issue needs to be addressed. User-supported software notices typically request "contributions." If you distribute user-supported software and receive contributions, you are receiving income and your contributor is making a purchase for federal tax purposes. Unless you are a registered tax-exempt organization, do not suggest that contributions are tax deductible (unless, of course, they legitimately qualify as business expenses).

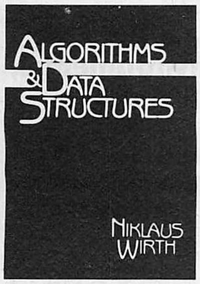
If you decide to place your software in the public domain for the good of mankind, blessings on you. Just remember that even good works have eventual consequences.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard with offices in Maryland, Virginia, and the District of Columbia.

A Classic Revised

Wirth's remake of his Algorithms + Data Structures = Programs *offers basically the same text as the original, with examples in Modula-2 rather than Pascal.*

Algorithms and Data Structures
Niklaus Wirth (Prentice-Hall; Englewood Cliffs, New Jersey; 1986) 288 pages, hardcover, $34.95



Niklaus Wirth, the man who invented the Pascal and Modula-2 programming languages, has revised his classic *Algorithms + Data Structures = Programs* (1976). The new edition, entitled *Algorithms and Data Structures*, gives examples in Modula-2 rather than Pascal. Apart from this, most of the original text has been left unchanged.

Unfortunately, this new edition is poorly typeset. As a result, although the new edition still deserves to be called a classic, readers who do not particularly need the new Modula-2 examples may prefer to continue using Wirth's earlier version of the book.

The purpose of the book is to explain why Wirth designed Pascal and Modula-2 the way he did. His goal was to make these languages simple, but expressive, on the principle that a few simple features, carefully chosen, can be put together to build powerful programming tools. Therefore, in *Algorithms and Data Structures*, Wirth concentrates on how programmers can use the features of Modula-2 to implement their own ideas.

The book's greatest strength is that it bridges the gap between formalized mathematical treatments of algorithms and practical, how-to books about programming. In this book, the programming language *is* the formalism—Wirth achieves a high level of abstraction while writing all his examples in a real programming language.

The book begins with fundamental data structures. Most programming languages do not really have a *concept* of type, only an *inventory* of types, such as real, integer, character, and Boolean. Wirth's main insight is that a type is a range of possible values. Thus, it makes sense to define not only "integer" but also "positive integer," or even "integer between 10 and 20," as data types in a language. Pascal and Modula-2 allow users to do just that. Subranges, records, and arrays are discussed exactly as in Wirth's earlier book.

The section on files in the new edition has been completely rewritten. In Pascal, a file is an object from which characters are extracted, and the functions **eof** and **eoln** look into the future to warn of an approaching end-of-line or end-of-file mark. (These functions were impossible to implement for keyboard input, because the system cannot predict whether the user is about to press Enter, creating an end-of-line mark.) In Modula-2 this need for looking ahead has been removed; an end-of-file mark is detected by actually trying to read past it. A file is mapped onto a data structure called a *sequence*, which is, basically, a potentially infinite array.

The first chapter ends with a new section on searching, including the standard linear and binary search techniques and the recently discovered Knuth-Morris-Pratt and Boyer-Moore string search algorithms.

Sorting is covered next. Wirth points out that simple sorting methods, although inefficient, are easy to remember and to code. After analyzing the performance of such methods, he observes that "Bubblesort has hardly anything to recommend it except its catchy name." According to Wirth, the most useful of the simple sorting algorithms is the straight selection method. More complex sorting methods, such as recursive algorithms and algorithms that depend on merging separate work files, also are covered in this chapter.

Wirth points out that in most textbook examples of recursion, the recursion used in the example is not really needed to solve the problem, which may be why so many programmers view recursion with a vague uneasiness. Recursion is a tool of thought for programmers, not a feature of the computer hardware. It should be applied to problems that human beings naturally think of in recursive terms—that is, tasks embedded in other tasks of the same kind. Wirth shows how to transform simple recursive programs into nonrecursive form. In addition, he illustrates recursion with Hilbert curves and backtracking problems.

Chapter 4 begins with the observation that a linked list is a recursive data structure—it can be thought of as a record containing another record of the same type. From this starting place, Wirth moves on to explain pointers, list manipulation, binary trees, and B-trees (which are search trees that can conveniently be broken up into more than one record or file). To complete the discussion of search methods, a new section on priority search trees has been added at the end of this chapter.

The final chapter, which covers hashing, was originally part of chapter 4 in Wirth's first edition. The chapter on parsers and compilers that ended the first edition has been deleted in the revised edition, with a hint that Wirth may be working on an entire book on that particular subject.

The typography of the new edition is a big step down from the previous one. Wirth typeset the new edition himself on a laser printer, and the type is far too light (thin) for its size. On the whole, the book is hard to read. The spacing between lines is uneven and many typographical errors have been introduced. Do-it-yourself typesetting, however fashionable, is not yet sophisticated enough to be a truly satisfactory substitute for the traditional tools of the printing industry.

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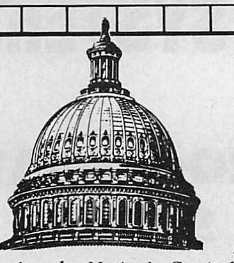

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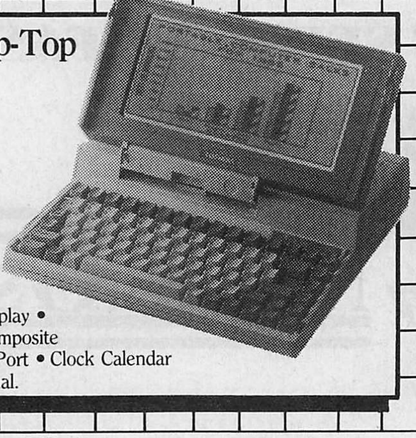

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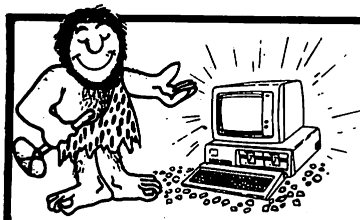

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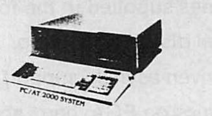

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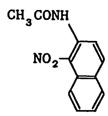

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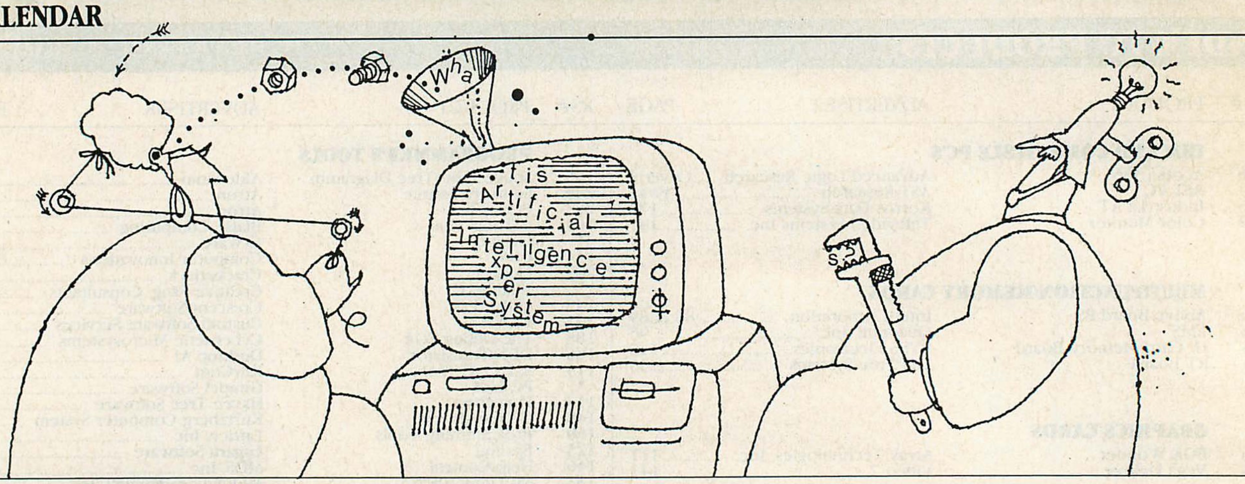

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Implementing Local Area Networks
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Sponsor: Integrated Computer Systems
Contact: Yolande Amundson, 5800 Hannum Avenue, P.O. Box 3614, Culver City, CA 90231; 800/421-8166, in Canada 800/267-7014

January 14-16
Computer Graphics '87: Hardware/Software Assessments and Forecasts
San Diego, CA
Sponsor: Frost & Sullivan
Contact: Carol Every, F&S, 106 Fulton Street, New York, NY 10038; 212/233-1080

January 20-23
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Sponsor: /usr/group
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January 21-23
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Contact: Steve Muchnick, Sun Microsystems, MS 5-40, 2550 Garcia Ave., Mountain View, CA 94043; 415/960-7233; or Mark Wegman, IBM T.J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598; 914/945-1327

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Micro-mainframe Links
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January 26-28
Artificial Intelligence: Practical Applications
Toronto, Ontario Canada
Sponsor: Digital Consulting Associates, Inc.
Contact: Seminar Services Department, 8 Windsor Street, Andover, MA 01810; 617/470-3880

January 28-30
Computer Graphics New York '87
New York, NY
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Contact: Justin Webb, EM&M, 8300 Greensboro Drive, Suite 690, McLean, VA 22102; 703/893-4545

FEBRUARY

February 2-6
Third International Conference on Data Engineering
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Sponsor: IEEE-CS
Contact: IEEE-CS, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903; 202/371-0101

February 12-13
Implementing DB2
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February 17-19
Computer Science Conference '87
St. Louis, MO
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February 23-24
Micro-mainframe Links
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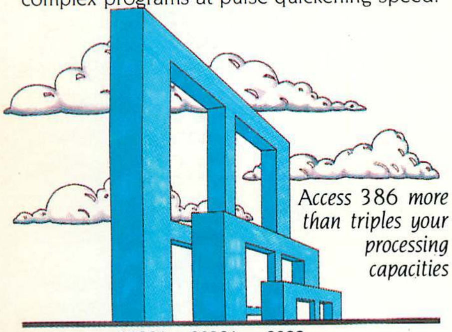

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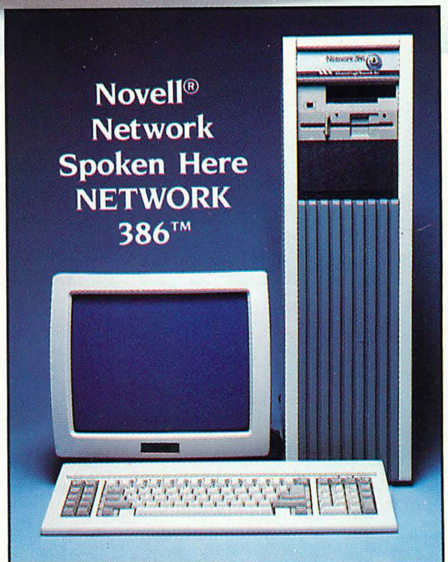

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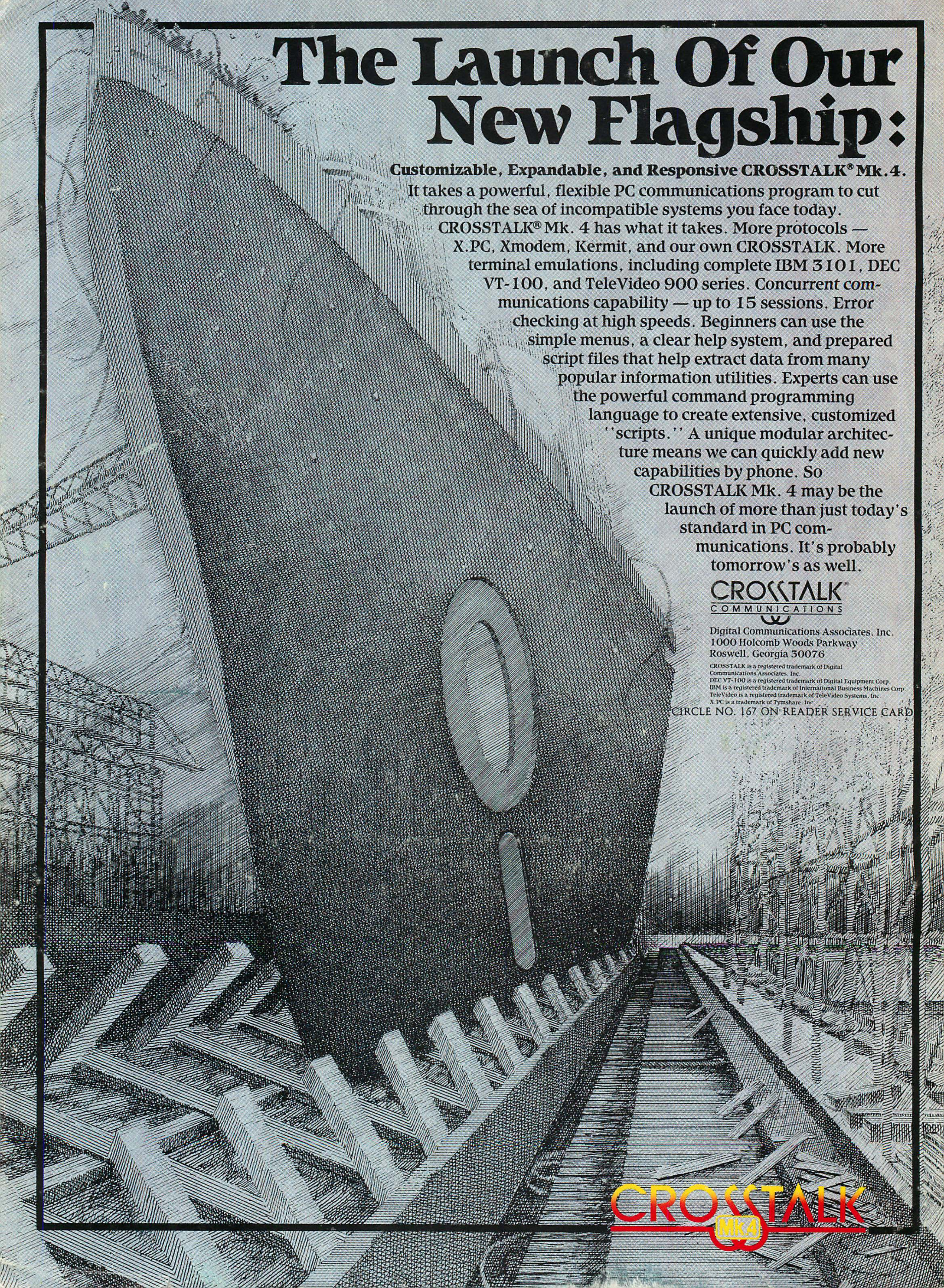
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